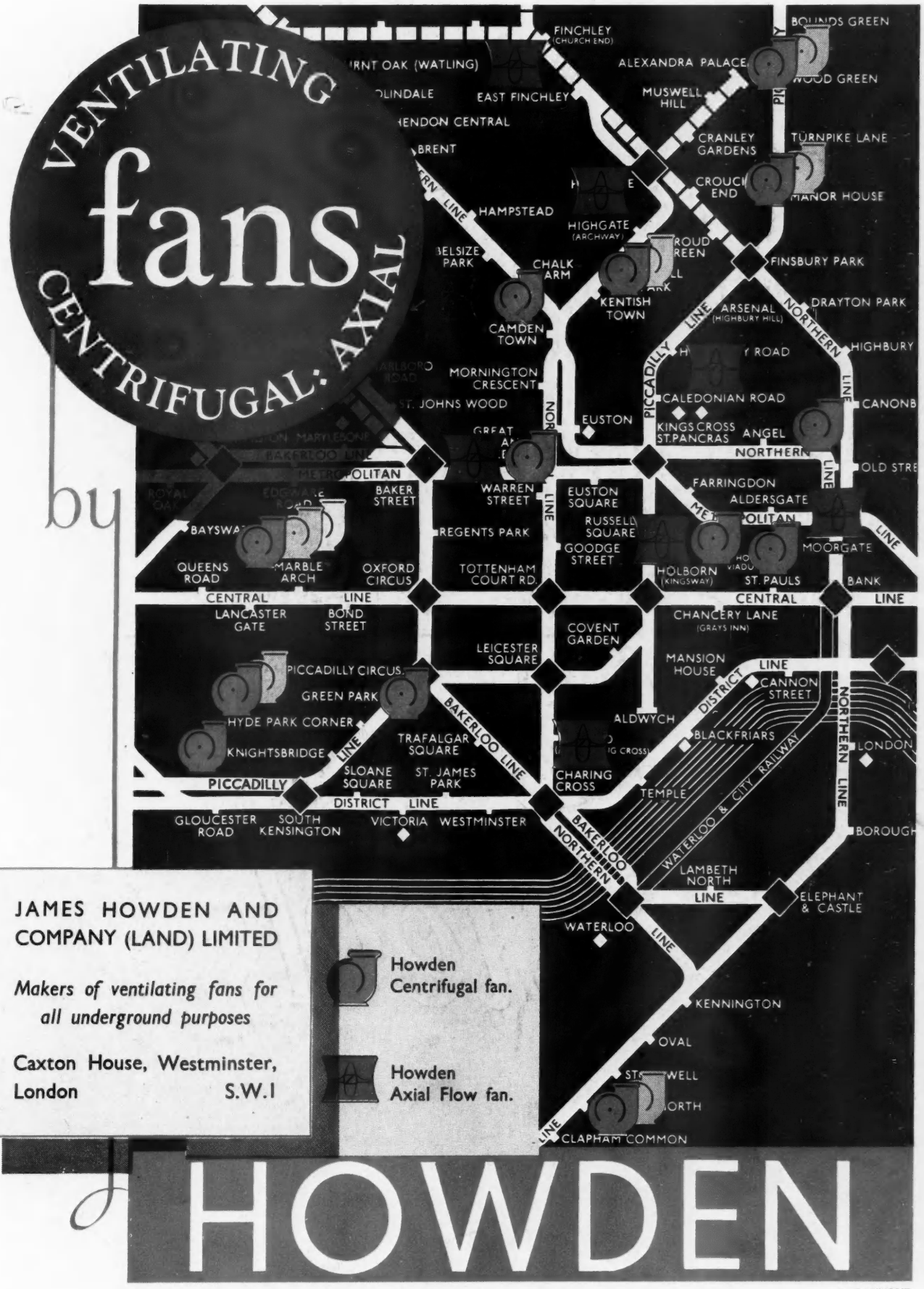
Printed on thin paper for overseas circulation.

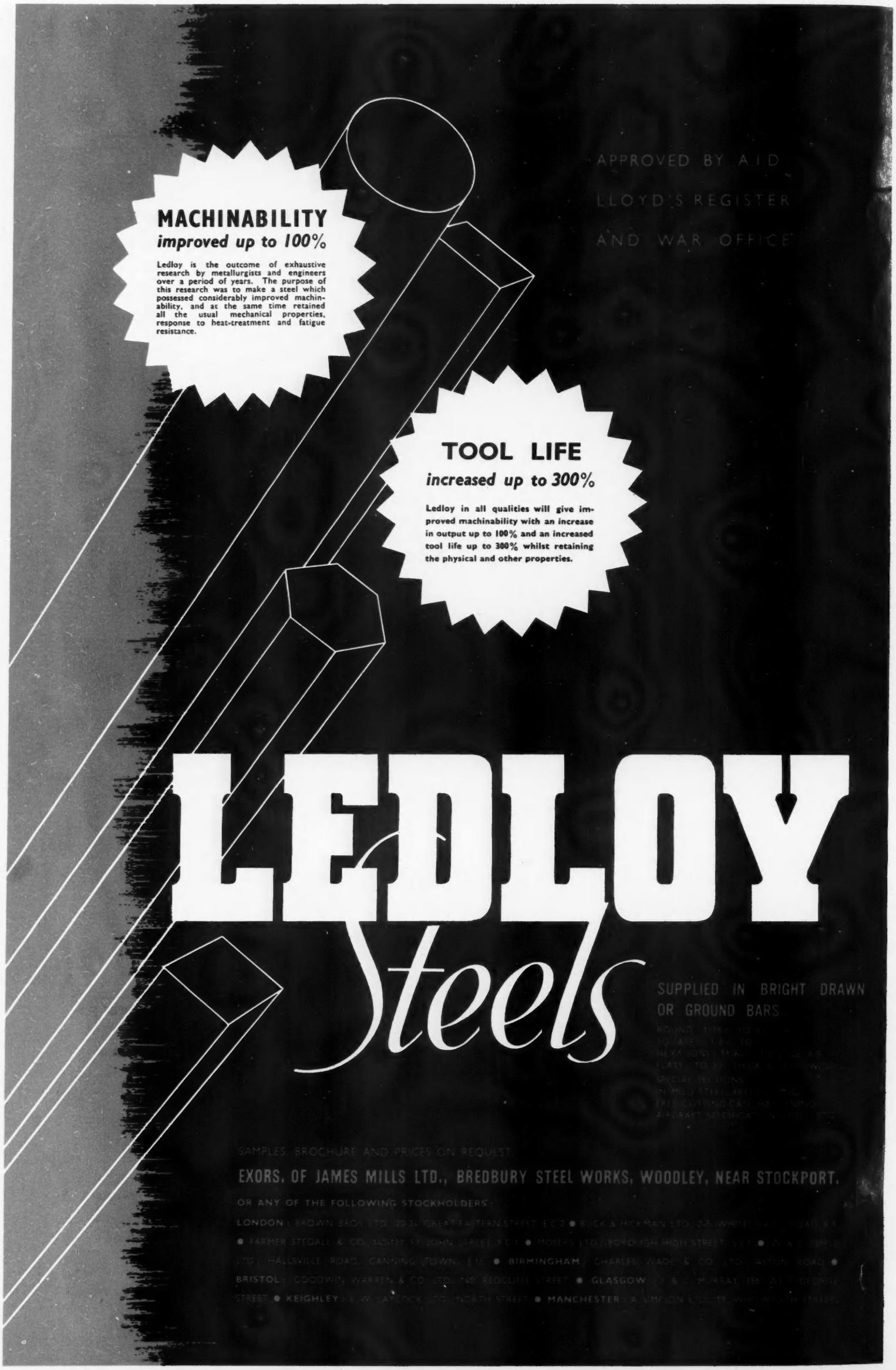
APR 10 1940

The Engineer

VOL. CLXIX.—No. 4393 28, ESSEX ST., STRAND, LONDON, W.C.2 MARCH 22, 1940

Established 1856 Price One Shilling, by Inland Post 1s. 3d. Registered as a Newspaper




APPROVED BY AID
LLOYD'S REGISTER
AND WAR OFFICE
MACHINABILITY
improved up to 100%
Ledloy is the outcome of exhaustive research by metallurgists and engineers over a period of years. The purpose of this research was to make a steel which possessed considerably improved machinability, and at the same time retained all the usual mechanical properties, response to heat-treatment and fatigue resistance.
TOOL LIFE
increased up to 300%
Ledloy in all qualities will give improved machinability with an increase in output up to 100% and an increased tool life up to 300% whilst retaining the physical and other properties.
LEDLOY
Steels
SUPPLIED IN BRIGHT DRAWN OR GROUND BARS
SAMPLES, BROCHURE AND PRICES ON REQUEST
EXORS. OF JAMES MILLS LTD., BREDBURY STEEL WORKS, WOODLEY, NEAR STOCKPORT.
OR ANY OF THE FOLLOWING STOCKHOLDERS:

A Seven-Day Journal

The British Electrical Development Association

THE annual luncheon of the British Electrical Development Association took place at the Savoy Hotel on Friday, March 15th, and was attended by over five hundred members and guests. The chair was taken by the President, the Right Hon. Earl of Lytton, and the guest of honour was Captain the Right Hon. Euan Wallace, Minister of Transport. Unfortunately, owing to illness, Captain Wallace was confined to his bed, but by the aid of the Post Office engineers he was able to introduce Mr. Robert Bernays, the Parliamentary Secretary to the Ministry of Transport, who proposed the toast of the British Electrical Development Association. Captain Wallace was also able to listen to the whole of the speeches. In the course of his speech, Mr. Bernays referred to the successful career of the association and its fortune in having at its head a man with the driving force and inspiration of Lord Lytton. Politicians, he said, envied the success of the association's "Million new consumers" campaign which had added no less than 800,000 new consumers. Electricity was playing an important part in our war effort. A new field, he thought, was the farming industry, in which over 200 different kinds of machines could be worked electrically. Although the black-out restrictions had reduced the standard of lighting in homes and industry, now that efficient black-out schemes had been put into operation there was no need why the reduced and depressing standard of indoor lighting which had been adopted in so many cases should be continued. The association could play a useful part in encouraging the reinstallation of an adequate standard of lighting. Another field of development for the association was to advocate an extended use of electric vehicles, which were admirable on short range work and had the merit of using home-produced fuel. It had been suggested that some 100,000 vehicles in Great Britain, now consuming petrol, could be replaced by electrically driven vehicles with a substantial saving in the consumption of petrol. As regards propaganda, although the urgent demands of public supply should be met, the steps taken by the electricity and gas industries to declare a truce to competition during the war period were, he thought, wise. When the war ended there would be an undoubted expansion in the use of electricity, which the association and the supply authorities would be in a position to meet. In reply to the toast, Lord Lytton referred to the beginnings and the growth of the work of the association during the last twenty-one years. Great advances had been made in the supply of electricity both for industrial and domestic uses, and he saw the possibility of still further progress being recorded in the agricultural industry, and in the development of the battery-driven transport vehicle for short range work.

Institute of Marine Engineers

THERE was a large attendance at the annual meeting of the Institute of Marine Engineers, which was held at the Connaught Rooms on Friday, March 15th, and more than 300 members and guests attended the informal luncheon which followed the meeting. The chair was taken by the President, Sir Percy E. Bates. After the presentation of the council's report, and the awards, a vote of thanks was accorded to the president, who in the course of his reply said that it had been a disappointment to him that the war had prevented the fulfilment of many of the public duties attaching to his office. He expressed the hope that he might serve as the "Peace President of the Institute." The members, Sir Percy continued, could depend upon him to do his best for them both as individuals and as a corporate body. As an officer of the Royal Naval Reserve, Sir Percy said that he had been struck by the relatively few engineer officers of the Merchant Navy which had joined the Reserve during peace time, compared with the number of deck officers. As a result there had been some little difficulty in arranging temporary commissions for Mercantile Marine engineers serving in what are now his Majesty's ships. At the luncheon, the toast of "The Institute of Marine Engineers" was ably proposed by Sir John Gilmour, the Minister of Shipping, who made reference to the marine engineer and the institute and congratulated Sir Percy on the safe passage of the "Queen Elizabeth" across the Atlantic, without any trials and those opportunities of testing the ship, which in the ordinary course of events would have taken place. In his reply, Sir Percy remarked that, in this age of mechanisation, machines and men needed, he thought, the same treatment, rest, overhaul, and lubrication. He assured Sir John on behalf of the marine engineers that if he provided these, particularly the last two needs, there was not the slightest fear that their side of the job would fail. The Ministry of Shipping was probably the largest user of marine horse-power in the world, and the Royal Navy, which was represented by Admiral Sir Charles Little, Second Sea Lord and Chief of Naval Personnel, and Engineer Vice-Admiral Sir George Preece, Engineer-in-Chief of the Fleet, was probably next. Much would be gained by the close association of naval and mercantile practice. Speaking on the peace-time tasks of the two "Queens" Sir Percy said that when he asked his superintendent engineer, Mr. Austin, as to the probable speed of the "Queen Elizabeth" he replied about 25 knots, or may be a bit over 32 should there be a German submarine about. In responding for the guests, Admiral Sir Charles Little referred to the benefit which the engineering branch of the Royal Navy obtained from the papers read at the meetings of the institute and published in its transactions.

The Late F. W. Bridges

MANY of our readers will learn with deep regret of the death in his eighty-first year of Mr. Frederick W. Bridges. He died at his home, Grindelwald, Hermitage Walk, South Woodford, on Wednesday, March 13th, following a short illness. Although not an engineer himself, Mr. Bridges had, through his long association with the publishing and printing trades, and his founding of the series of Engineering and Marine Exhibitions held at Olympia, gathered around him a wide circle of engineering friends. As a young man he worked on the staff of "The Ironmonger" for over twelve years, joining that paper in 1873, and only leaving it when he went to Australia in 1885. On his return to this country, he interested himself in publishing, and towards the end of last century Mr. Bridges became the proprietor of *The Press*, which later changed its name to *The Caxton Magazine* and was associated with the printing and allied trades. During the last war Mr. Bridges worked for the betterment of conditions in the printing trade, and as a direct result of his efforts there followed later the setting up of the Joint Industrial Council of the industry. For close upon forty years Mr. Bridges was interested in the planning and organisation of industrial exhibitions, among which we may recall the long series of trade and technical exhibitions which he organised in the interests of the engineering, electricity, foundry, laundry, gas, printing, stationery, welding, and music industries. Of these many successful undertakings THE ENGINEER was perhaps more closely associated with the fourteen engineering exhibitions, held mostly at intervals of two years, which F. W. Bridges and Sons, Ltd., organised at Olympia. To the engineering exhibitions, the first of which was held in 1906, were added foundry, welding, and marine engineering, and shipping interests, and the last engineering and marine exhibition was that of 1937. Had there been no war, an exhibition would have been held in 1939, and in that connection we included a pencil portrait of Mr. F. W. Bridges with our issue of September 15th, 1939.

Export Groups in Industry

IN one of last week's Journal notes we referred to the setting up of industrial export groups. At a luncheon recently given by the Birmingham Chamber of Commerce, Sir Andrew Duncan, the President of the Board of Trade, spoke on the need for increasing our export trade. Our great industrial and manufacturing structure was one, Sir Andrew said, that would not be readily adapted to the system of control and discipline which totalitarian states could impose with relative ease, neither was there any necessity for such a course. We knew full well the overwhelming importance of an expansion of export trade in a long war, and were ready to accept its challenge to our organising power. No magic formula could be devised for the purpose. The Government had come to the conclusion that it must create and establish export groups in the individual industries and work through those groups. He was pleased to say that already there had been an immediate and gratifying response to the Government's proposal. It was true that war might to some extent deprive us of our boasted individualism, but the trade organisation it was proposed to set up was not intended to suppress but rather to harness individual genius. It could be said that in this country such individual genius still resided alike in the small and the large firm.

Control of Shipping

IN a report which was presented at the recent annual meeting of the Liverpool Steamship Owners' Association criticism is expressed of the policy of the Government with regard to the general requisition of shipping. It is stated in the report that when war broke out the association was given to understand that the view of the Government was against a policy of general requisition, and in favour of a scheme of licensed voyages. The association is not aware of the reasons which have since led the Government to reverse its views, and it has not been consulted. The methods adopted since the beginning of the war with regard to ships placed at the disposal of the Government are outlined. The report goes on to state that the Government has no organisation either in this country or abroad capable of undertaking the management or running of such ships; and it has no authority to conscript the men employed ashore or afloat in keeping such ships in active service. It has therefore appealed to the British shipowners to continue to manage and run their own ships under the control of the Ministry of Shipping, and on account of the Government, but with as much zeal and care as if their interests alone were still involved, and the ships had not been requisitioned. The Ministry of Shipping has thus been placed in a position to promote, limit, or destroy our oversea trade on any route by increasing or restricting the ship carrying-power placed on such route. While the association views with anxiety the imposing of Departmental control over the British shipping and shipbuilding industries as a whole, its members, the report states, have "turned in a spirit of full co-operation to the task of operating both their ships and their organisations to the utmost benefit of the nation. The success of such co-operation must, it is felt, depend in a very great measure on the extent to which owners are allowed to carry on their business on normal business lines with the manufacturers and traders, and with the shipbuilders."

Birmingham Water Supply

A HOUSE OF COMMONS Committee has been considering a Bill of the Birmingham Corporation in connection with the city's water supply. The object of the Bill is to obtain consent to the abandonment of three reservoirs which were authorised to be constructed in the Birmingham Corporation Act of 1892, and for permission to construct in their place one reservoir on the River Claerwen. A dam which it is intended to build on the river will give a storage capacity of 10,860 million gallons a year or about 4000 million gallons more than the capacity of the three intended reservoirs under the Act of 1892. In his evidence before the Committee, the deputy water engineer of the Birmingham Corporation said that the city takes 45 million gallons a day from the existing yield of 72 million gallons a day from the Elan valley; the remaining 27 million gallons are compensation water. The total capacity of the Elan aqueduct is 55 million gallons a day. If the Birmingham demand should increase, water could be supplied up to 55 million gallons a day, but for a short time only. If more were taken than at present it would be at the expense of the reserve that is an inherent part of any properly-conducted water supply. It is estimated, he said, that the construction of the three dams under the 1892 Act, and contingent works, would cost more than £900,000 above the cost of building the single reservoir as proposed in the Bill.

War Work for Small Firms

IN the effort to bring the small industrial establishments into war production, 110 Chambers of Commerce throughout the country, at the request of Mr. Burgin, Minister of Supply, are to co-operate. These organisations are all members of the Association of British Chambers of Commerce. Mr. R. B. Dunwoody, secretary of the association, we learn, has received a letter from the Ministry in which it is stated that in setting up an area organisation throughout Great Britain and Northern Ireland, one of the objects which the Minister desires to attain is to bring increasingly into production some of the available engineering capacity of the smaller industrial establishments. It is proposed to examine the offers of capacity of all those firms which wish to be considered for munitions production through the medium of the area advisory committees and the area boards which have been or are being set up. The task of bringing the smaller industrial establishments into war production is one in which the Ministry desires to enlist the active help of the industrial organisations of the country. With this end in view, the letter continues, the Ministry asks whether the Association of British Chambers of Commerce could assist the Ministry by inviting the secretaries of local Chambers of Commerce to render what practical help they may be able to give, in an advisory capacity, to the secretaries of the area boards, who are the channel to the advisory committees for the reference of all offers of capacity. It will be recalled by our readers that secretaries of Chambers of Commerce have agreed to give every possible assistance to the secretaries of the area boards, which consist of representatives of the Admiralty, Air Ministry, Ministry of Labour and National Service, and the Ministry of Supply. It is possible that representatives of the Board of Trade will be added in the interests of export trade. The area boards are advised by area advisory committees which are composed of representatives of the Engineering Employers' Federation and the Trades Union Congress General Council.

D

Fifty Years of Marine Engineering*

By PROFESSOR A. L. MELLANBY, D.Sc., LL.D., Hon. M.I. Mech. E.

No. I

Reciprocating Engines

Proposals for Weight Reduction.—If we direct our attention to the ordinary reciprocating marine steam engine, the first impression will be the apparently small change that has taken place in the general appearance of the engine over a period of fifty years. This will be recognised by referring to Fig. 1, which shows an engine constructed by

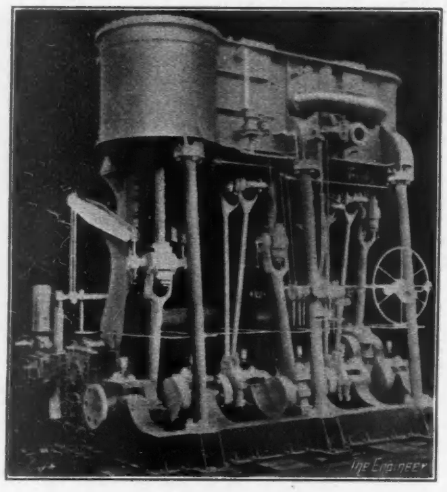


FIG. 1—RECIPROCATING ENGINE OF 1887

the Central Marine Engine Works in 1887, in the building of which I may be supposed to have played some small part. In Fig. 2 is shown another engine representing the latest practice of the same firm. A careful study of the details of the two engines, so far as they can be seen in these illustrations, will be found worth while. The actual changes in design may become more evident as this lecture proceeds, but it is well to note that many of the improvements which we now consider to be representative of modern practice were advocated and had their claims presented to the engineering world by the pioneers of the last century.

Reduction in weight, coupled with improved efficiency and reliability, have been the aim of designers for many years and so we shall find

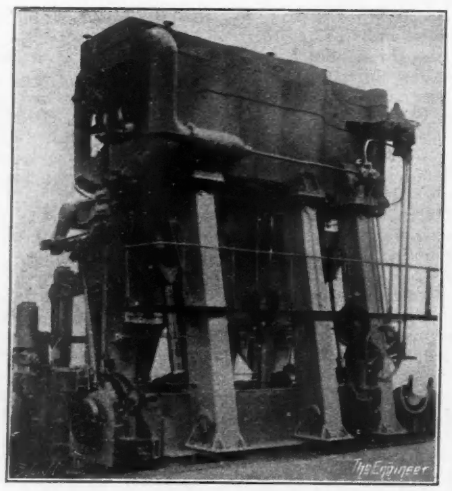


FIG. 2—RECIPROCATING ENGINE OF 1939

numbers of papers dealing with effects of speed, influence of boiler and condenser pressure, and the results to be obtained by varying cylinder ratios scattered through the Proceedings of the Institutions during the last fifty years.

The first paper to which I would draw your attention is one presented to the North-East Coast Institution of Engineers and Shipbuilders by Messrs. Marshall and Weighton (1885–86). Here a plea is made for weight reduction, and although the proposals put forward are primarily intended for the most modern types of vessels of war, yet it is indicated that many of the suggested changes could with advantage be used to save dead weight in merchant vessels. In considering the effect of pressure the following cautious statement is made: "that coal economy increases considerably with higher boiler pressures is a fact established by natural law and now amply confirmed by practice for pressures up to at least 180 lb. per square inch." Doubt is, however, expressed upon the influence of high pressure on weight, and from experience up to that date it is suggested that, when a pressure of 100 lb. per square inch is exceeded, it does not much matter what particular pressure be adopted, so far as concerns the power which can be derived from a given weight. The main emphasis is placed upon the importance of increased piston speed, but attention is also called to the necessity for special design when speeds such as those proposed are adopted. Of interest is the warning that the main distribution valves are likely to give trouble unless special attention is given to the forces set up in the valve gearing while working at high speeds of reciprocation, a point that is emphasised by the introduction of a diagram showing the actual stresses, as indicated by a dynamometer, set up in the valve spindle of the low-pressure cylinder of an engine running at high speed.

The importance of suitable material is properly stressed and it is stated that, for many parts, steel, both wrought and cast, is essential. Of some significance is the statement that "forged steel as now produced is very reliable and from its physical properties is admirably adapted for such parts as piston rods, connecting rods, valve gears, bolts, and shafting. If tested under careful supervision it may with confidence be loaded to an extent 50 per cent. in excess of good average wrought iron." There is, however, a somewhat modern touch in the statement that "of cast steel, one has to speak with more reserve owing to the difficulty still experienced by steel makers in producing castings sufficiently free from defects." It is probable that most members have heard similar statements, expressed in feeling terms even in comparatively recent times.

There is also a present-day sentiment in the paragraphs dealing with boilers and forced draught, where it is emphasised that "while *speed of piston* is the feature which chiefly distinguishes the class of engines with which we are dealing, *forced draught* is no less the characteristic of the boilers which are usually associated with these engines." The importance of forced draught in weight reduction is strongly urged and the statement made that with a plenum in the stokehold of from 2in. to 2½in. water gauge the power can be quite readily increased 50 per cent. Criticism, on the lines of the general impression that forced draught is exceedingly wasteful of fuel, is anticipated by the presentation of a series of boiler tests where results are given quite up to the standard of natural draught combustion.

I have quoted largely from this paper because I believe it brings home to us, although written more than fifty years ago, how essentially modern the authors were in their outlook and how real an appreciation they had of the essentials of the problems with which they were confronted.

Speed Reduction Gear Proposal.—Another noteworthy contribution to the weight reduction problem was made by Mr. E. Hall-Brown (1889–90). In his paper the author directs special attention to the efficiency of the propeller and rightly points out that the efficiency of the propelling machine is not measured by the coal consumption per indicated horse-power-hour but by the coal per hour usefully exerted at the propeller. In developing his argument the propeller experiments of Barnaby are drawn upon and curves presenting the change of efficiency with propeller speed are referred to. Such curves show how the efficiency of a propeller increases largely with speed of revolution until the maximum efficiency is obtained; beyond this speed of revolution the efficiency decreases, but more slowly. Slight variations above or below the proper speed of revolution have little effect upon the efficiency and consequently it may be admissible to run the propeller slightly faster than the proper speed in order to reduce the size and weight of the engines. Such variations are, however, greatly restricted and the author points out that to exceed the speed of current practice so as to produce any appreciable weight-reducing effect would be out of the question. Thus it follows that the propeller is an effectual bar to the adoption of high-speed engines in cargo boats unless means are adopted whereby the engine may run at any desired speed while the main shafting revolves at the speed best suited for the propeller. The obvious solution to the problem is the employment of gearing and this Mr. Hall-Brown boldly advocates, intimating at the same time that he did not make any claims for originality in the suggestion. From a study of the discussion following this paper it will be noticed that the proposal to run the propeller comparatively slowly at the rate of revolution best suited to it while the engine ran at a much greater speed was not received with enthusiasm. Many of those present could remember when all large screw engines were geared engines, but with this difference that the engines were then running more slowly than the propeller. To forsake the simplicity that had then been gained by coupling the engines direct to the propeller appeared to be a backward step and as such could not be supported. Now that gearing is so largely employed in the marine service both for turbines and reciprocating engines, some astonishment may be felt by our younger engineers that there should have been serious objection to its adoption, but it is well worth recording, in view of present practice, that the principle was suggested in all seriousness fifty years ago.

Whilst on this question of engine speeds it may not be out of place to mention that in a paper given by Mr. F. C. Marshall to our own Institution in 1881 reference is made to a three-crank compound engine working under a boiler pressure of 90 lb. per square inch with a piston speed of 605ft. per minute. By 1889 Atlantic liners were working with piston speeds of 900ft. per minute and machinery had been designed by Messrs. R. and W. Hawthorne, Leslie and Co., Ltd., for the Italian Navy to run with a piston speed of 1020ft. per minute.

Necessity for Trials at Sea.—At this period much discussion took place upon engine and boiler performances at sea; and the advantages to be obtained from making measurements of feed water, coal, and horse-power with the ships in actual service were often stressed. In this direction our own Institution played a prominent part and by instituting the Marine Engine Trials Committee initiated a policy which must have had a very great influence upon marine engineering. The appointment of this Committee may have been largely influenced by a paper presented to the Institution by Mr. R. Wyllie in 1886. This paper dealt with the general design of marine engines and enumerated the principal features that were supposed to be associated with maximum efficiency. In view of modern development it is worth while noting the following statement made in the early part of the paper: "The most important conditions to be considered in order to obtain an efficient engine are that there should be approximate equality—firstly in the range of temperature in each cylinder; secondly in the initial stresses on each crank; and thirdly in the indicated horse-power of each cylinder." This stress upon the importance of equal temperature ranges in each cylinder appears repeatedly throughout the paper and discussion, while references are also made to the fact that the steam consumption, as shown by the indicator card, did not measure more than about 75 per cent. of the steam actually used. During the discussion of the paper an invitation was extended by Mr. D. B. Morison to Professor Kennedy to take part in a trial trip from Hartlepool to Plymouth, where he would be given every assistance for taking indicator diagrams and measuring the coal consumption.

In the Annual Report of the Council for 1887 it is mentioned "that a Research Committee has been appointed to draw up a standard system for conducting Marine Engine Trials and to arrange for the carrying out of such trials in accordance with this system. The organisation of this research has been kindly undertaken by Professor Kennedy." This committee rapidly got to work and the first trial trip of the S.S. "Meteor," in which measurements of indicated horse-power, feed water, coal, &c., were organised and supervised by the committee, was made in June, 1888. The first report of the committee appears in our Proceedings

* From the Thomas Lowe Gray Lecture, Institution of Mechanical Engineers, March 15th.

for 1889. The vessel was fitted with triple-expansion engines working under a boiler pressure of 145 lb. per square inch. The results of the trial showed that the boiler efficiency was about 62 per cent. and that the steam consumption of the engines was 15 lb. per I.H.P.-hour. The usual remarks about initial condensation were made by several of the speakers in the discussion, largely bearing upon the note made in the report to the effect that the steam shown as present in the high-pressure cylinder at cut-off was about 77 per cent. of the total feed. General satisfaction was expressed with the report and all acknowledged that it had shown not only what a particular set of fairly representative engines and boilers was actually doing, but also that these results had been obtained under conditions which did not interfere with the ordinary working of the engines at sea.

With undiminished energy the committee went on with their work and in 1890 a second report was presented, dealing with the trials of three vessels. The first was the "Fusi Yama" fitted with a two-cylinder compound engine under boiler steam at 60–70 lb. per square inch. In describing this it was stated that "the engine was in reasonably good order and reasonably economical; and such engines are used by hundreds throughout the mercantile marine and often on long voyages without special pretensions to economy." The second and third vessels were the S.S. "Colchester" and the S.S. "Tartar." The "Colchester" was a twin-screw vessel fitted with two-cylinder compound engines. The "Tartar" was described as a fine example of the triple-expansion engines used in large cargo vessels working with a boiler pressure of 140–150 lb. per square inch. The "Fusi Yama" showed a boiler efficiency of 67 per cent. and a coal consumption of 2·66 lb. per I.H.P.-hour. The "Colchester" had a boiler efficiency of 62 per cent. and a coal consumption of 2·9 lb. per I.H.P.-hour and the "Tartar" was in the first instance given a boiler efficiency of 84 per cent. and a coal consumption of 1·82 lb. per I.H.P.-hour. This high efficiency figure was questioned and after further analysis it was estimated that the boiler was producing very wet steam and that the real efficiency was about 70 per cent. The generation of wet steam was confirmed by the fact that the steam shown by the indicator to be present in the high-pressure cylinder at cut-off was only 45 per cent. of the total feed.

The discussion on this report was a notable one and showed convincingly how much the information it gave upon the machinery performance at sea was appreciated by engine and boiler makers. It also stressed the necessity for using some instrument to determine the dryness fraction of the steam leaving the boilers and a particularly interesting piece of information was given by Mr. Willans, on the influence upon the power developed in his own engines of a copper coil fitted near the bottom of the low-pressure cylinder and supplied with boiler steam.

In 1891 a report was given upon the S.S. "Iona," a vessel fitted with triple-expansion engines with a boiler pressure of 165 lb. per square inch. The boiler efficiency was given as 69 per cent. and the coal consumption as 1·46 lb. per I.H.P.-hour. I might mention that I have a special feeling towards this report since the engines were built at the Central Marine Engine Works where I was then serving my apprenticeship and that, before the trials, the committee visited the works, probably to see the engine under erection. I can still remember the feelings of awe and admiration felt by many of us when it became known what a distinguished body of engineers was among us.

In 1892 another report was presented dealing with the performance of the "Ville de Douvres." The interesting feature of this trial was that the vessel belonged to the Belgian Government and that assistance in making the observations was given by several Belgian scientists. Finally, I would refer to the paper appearing in the Proceedings for 1894 written by Mr. (now Professor Sir Thomas) Hudson Beare, in which a general comparison is presented of the whole of the trial results. A study of this paper is well worth while since it gives an excellent presentation of the powers, consumptions, and efficiencies of so many vessels that were then typical of the different classes of marine service.

Necessity for More Detailed Information than can be Gained from Sea Trials.—I have particularly emphasised these trials since they represent the general commencement of that policy of experimental research which has been since then a special feature of marine engineering. But it will be noticed that the experience gained from those trials had only a limited application. It is true that large departures from the proper lines could be noted and obvious inefficiencies could be corrected. It was, however, noticeable that very few conditions could be changed when once a vessel was in service and that effects upon efficiency due to variations in number of expansions, in cylinder proportions, in changes of the point of cut-off in intermediate- or low-pressure cylinders, or in crank angles, could not be determined. The necessity for exact information upon such points was recognised by all marine engineers and it was due to this recognition that the provision for a programme of well-organised research was soon made.

Newcastle Experiments.—In 1891 the late Professor R. L. Weighton was appointed to the Chair of Engineering at the Durham College of Science (now King's College), Newcastle upon Tyne. His long association with marine engineering design and manufacture in Glasgow and Newcastle had acquainted him with the problems principally occupying the attention of designers, and he well understood in what particular direction experimental research was necessary in order to carry the movement for increased efficiency to a higher stage. He had the happy idea of associating the marine engineers of the North-East Coast with his programme of research and of obtaining their assistance in procuring the experimental plant upon which his researches could be made.

The engines and boiler, which he designed in full detail, were a free gift to the College contributed by between 40 and 50 firms, mostly situated on the North-East Coast. In a paper describing the engines and giving the results of some of his experimental work, Professor Weighton (1896–97) states that "the engines and boiler were contributed on a system which seems to be unique in the history of such matters." The engines, designed mainly for research work, were of the vertical marine condensing type, capable of working single, double, triple, or quadruple expansion, on four separate cranks. The boiler was of the ordinary single-ended multitubular marine type designed for a working pressure of 210 lb. per square inch.

Mean Effective Pressures.—Before speaking of the information given to the engineering world by this experimental plant it might be advisable to mention some of the problems that were then exercising the minds of marine engineers. One of the most important was that associated with the number of expansions that should be given to the steam for the most efficient working of the engines. The general belief was that a large number of expansions was associated with maximum economy, a conclusion which would appear to be fairly reasonable when nothing more than the expansion curve of steam is studied. The difficulty here raised is that a high expansion rate neccessitates a low mean effective pressure and consequently a larger engine is required for any particular power development than if one were content to let the steam pass into the condenser at a higher release pressure. It seemed, therefore, that the choice lay between a large and consequently costly engine with a low steam consumption and a smaller, cheaper, and less weighty engine with a high consumption. On the whole it appears to have been the general desire to use the large engine, hoping that the reduced coal consumption would more than counterbalance the extra first cost and reduced cargo-carrying capacity.

Initial Condensation.—Another subject of general discussion was that of initial condensation in steam engine cylinders. Reference to this appears in most of the papers of that time dealing with steam engines, and discussions upon its extent and importance will be found in practically every engineering text-book of that period. It seems to have been a very general belief that "initial condensation" was the main enemy to be overcome before any great advance could be made in engine economy. Even to-day in spite of the knowledge that has been gained by experimental workers, the prevalent belief in the importance of initial condensation is still very widespread and most of the information available as to the real nature of this phenomenon appears to be either unknown or ignored. It may be remembered that in the earlier part of this lecture mention was made of the supposed importance of dividing the total temperature range equally between the three cylinders of a triple-expansion engine and of the beneficial effects that were supposed to arise if this could be attained. It is difficult to appreciate the reasons for this belief, but it is certain that it was strongly held and had a great influence in the cylinder proportioning and the power distribution among the different cylinders. It was generally with a feeling of regret that it was found almost impossible, with reasonable design, to bring the temperature range in the low-pressure cylinder down to that of the high-pressure and intermediate-pressure cylinders. The strange thing is that the amount of surface exposed to the steam appeared to be taken very little into account, although it was obvious that the surface exposed, up to cut-off, to the influence of the entering steam would be much greater in the low-pressure than in the preceding cylinders. It is, however, worth noting that in the discussion on Mr. Wyllie's paper (1886) it was pointed out by Professor Ryan that it was not proved that inequality in range of temperature caused any large amount of evil through condensation and also that initial condensation depended not only upon the temperature range but also upon the amount of surface exposed to the steam.

Economy and Mean Effective Pressure: Experimental Results.—With this necessarily incomplete review of the position concerning engine size and provision for the reduction of initial condensation some consideration may now be given to the changes in practice that have resulted from experimental research. The problem of number of expansions was conclusively settled by the first series of tests carried out by Professor Weighton upon his experimental engine. The tests were made with the engine working with quadruple expansion under a boiler pressure of 210 lb. per square inch and with power development varied by changing the number of expansions of the steam. Some of the results obtained are shown in Fig. 3, where steam consumption, in terms of steam per brake

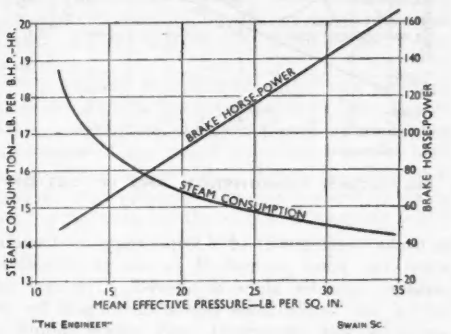


FIG. 3—STEAM CONSUMPTION AND MEAN EFFECTIVE PRESSURE

horse-power-hour, is plotted against mean effective pressure referred to the low-pressure cylinder. The important conclusion to be drawn from this diagram is that the curve of steam per brake horse-power-hour shows that, within the limits of the trials, a minimum value has not been reached and that for maximum efficiency an even higher value of mean effective pressure than about 35 lb. per square inch might have been used.

In presenting his paper the author emphasised that the practical lesson taught by the tests was that engines should be made small for the power developed. To illustrate this point he estimated the dimensions of two quadruple-expansion engines with specified power, pressure, and speed conditions, one designed for a mean effective pressure of 20 lb. per square inch—a figure that up to then had been supposed to approach the ideal—and the other with this pressure raised to 35 lb. per square inch, a figure suggested by the trials under consideration. Under the first condition the diameter of the low-pressure cylinder would be 71in. and under the second condition it could be reduced to 52in. In addition, the smaller engine would require 6½ per cent. less steam than the larger one and consequently the boiler size could also be correspondingly reduced.

In the discussion which followed surprise was expressed at the results, so much at variance with pre-conceived notions, but there appeared to be a general agreement that they represented facts and that old ideas upon efficiency and mean effective pressure would have to be changed. Such a readjustment of ideas has been made and the information available from the trials has had a profound effect upon marine practice. Builders who had often been compelled to supply small engines owing to the influence of first cost were now able to congratulate themselves upon the fact that this cheapness was associated with reduced running expenses. Those interested in this question of mean effective pressures are recommended to refer to a paper written by Mr. R.

Royds (1906–7) where they will find much valuable information upon the efficiency of many classes of steam engine under varying steam expansions.

Cylinder Ratios.—A further point of interest to marine engineers of fifty years ago was the proportioning of the power developed between the different cylinders of a multiple-expansion engine. As previously mentioned, equality of temperature range and of power development in each cylinder were considered by many as essential features at which to aim. The former might be regarded with suspicion by some as verging on the theoretical, but the latter was looked upon as of real practical value. Experiment, however, indicated that neither of these ideals might be correct and a second set of trials made in Newcastle produced results that enabled the fixing of cylinder proportions and power distribution in multiple-expansion engines to be put upon a sound design basis. The account of these trials will be found in a paper by Professor Weighton (1899–1900) entitled "Receiver Drop in Multiple-Expansion Engines," where are described experiments made to determine the most economical point of cut-off in the larger cylinders of multiple-expansion engines.

Some idea of the nature of these trials will be obtained by an examination of Fig. 4, which shows the increase in steam consumption and the changes

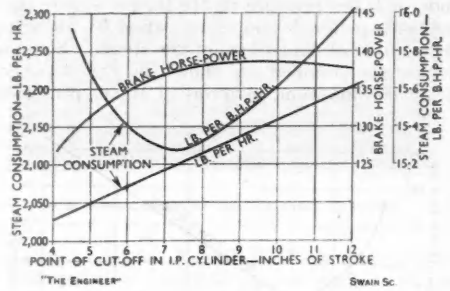


FIG. 4—STEAM CONSUMPTION AND I.P. CUT-OFF

in brake horse-power of a triple-expansion engine when the point of cut-off in the intermediate-pressure cylinder alone is altered. The rise and fall of the brake horse-power developed by the engine is well illustrated, and notice should be taken of the continual rise in steam consumption as the point of cut-off is made later. Any difficulty in appreciating why, under such conditions, the steam consumption will alter will be solved when it is appreciated that with later cut-off in the intermediate-pressure cylinder the back pressure in the high-pressure cylinder will fall. Similar results were obtained by varying the point of cut-off in the low-pressure cylinder although, as might have been anticipated, the increase in steam consumption with later cut-off is less marked.

By using different cylinder ratios, as was possible with the four cylinders at his disposal, Professor Weighton was able to obtain an expression from which could be calculated the most efficient point of cut-off in any cylinder after the high-pressure one for any multiple-expansion engine, and, as pointed out during the discussion, the results could also be used for making a very close approximation to the best ratio of cylinders for any predetermined total number of expansions. It will also be recognised that these experiments disposed, once for all, of the notions that maximum economy was associated either with equality of power development or with equality of temperature range in the several cylinders.

Researches in Initial Condensation.—The subject of initial condensation was mentioned at an earlier stage of this lecture, and although the loss represented by the increase in steam consumption is common to all reciprocating engines, yet it will have been noted that marine engineers took a keen interest in what was then considered to be a most serious obstacle to high engine efficiency. The early success of Watt through introducing the separate condenser and thus avoiding the admission of steam to a cylinder that had just received a violent cold water spray appeared to delude many people into the belief that still further great improvements could be attained by diminishing the loss due to the temperature rise and fall of the working steam alone.

Obviously if steam entering a cylinder is condensed it is because the surface of the metal with which it comes into contact is below saturation temperature. The cooling of the metal results from contact with the steam during expansion and exhaust so that there will be a cyclical rise and fall of temperature of the cylinder surface just as there is a cyclical rise and fall of the steam temperature and pressure. The difficulty that arises, however, is to determine what the range of the metal temperature is. Originally it appears to have been believed that the surface temperature of the cylinder walls followed closely that of the steam, and judging from statements occasionally made there are quite a number of people who still hold this idea. If it were true the steam consumption of engines would be enormous. This was shown by Professor Cotterill in his book "The Steam Engine" (1878), in which he gives an admirable analysis of cyclical heat changes and shows the relationship between the temperature range of the metal and the heat extracted from the steam. His conclusion, formed from a close examination of engine trial results, is that the temperature range of the metal surface must be appreciably less than that of the working steam. At the same time, Professor Cotterill believed that initial condensation was a very important factor in steam engine economy and he makes the statement that we have only to compare the surface of the cylinder with the surface of an ordinary surface condenser to see that the former is far more effective as a condenser than the latter. If further proof is required of the vast importance associated with initial condensation I have only to refer you to our own Proceedings, where you will find papers by Colonel T. English dealing with this subject (1887, 1889, 1892, 1894, 1896) and further papers by Bryan Donkin (1895, 1896, 1900), the second of which was published jointly with Colonel English. In all of these papers will be found the belief that initial condensation was relatively large in every engine and that the difference between the quantity of steam as shown by the indicator card and that actually used by the engine was present in the cylinder in the form of water.

The real solution of the problem was given in a paper presented to the Institution of Civil Engineers by Callendar and Nicolson (1897–98). There it was shown that the cyclical temperature fluctuation of the metal surface was nothing like that of the steam and that under all normal circumstances it was so restricted that it could be responsible only for a small proportion of the "missing quantity." From this it followed that the difference between indicated and actual weight was due to initial condensation plus valve leakage and that in the majority of engines using saturated steam the latter was by far the greater of the two. It is surprising that this paper is now so little appreciated and that the belief is still prevalent in some quarters that in many engines something between 30 and 40 per cent. of the steam present in the cylinder at the point of cut-off is in the form of water. Even in some fairly modern text-books absurd analyses are made of heat exchanges between cylinder walls and steam based on the assumption that the steam in the cylinder is a constant quantity, while the temperature-entropy diagram is used to show entirely wrong estimates of the condensation and re-evaporation during expansion. Before leaving Callendar and Nicolson's paper I must mention that it contains what I believe is the first reference to supersaturation in any engineering paper. Evidence is produced to show that even in an engine cylinder the steam may be in a partially supersaturated state during expansion.

If I have succeeded in interesting you so far, you will, I hope, be willing to agree that the experimental work to which I have referred has placed the marine engine builder in a much more satisfactory position. He now has a good idea of the steam consumption of marine engines of many different types; his information upon the mean effective pressures upon which are based his calculations for engine size is definite; and he has been freed from the nightmare of uncontrolled initial condensation and has only the minor problem of preventing excessive valve leakage to consider.

Condensers

It was in the 1900's, and largely through the successful operation of the steam turbine, that general attention began to be directed towards the surface condenser. Especially did stress begin to be put upon the fact that the presence of air in the condenser had a great influence upon plant performance. Very few engineers had apparently realised that the pressure in a condenser was made up of air pressure plus vapour pressure and that the temperature of the condensate corresponded to the vapour pressure. It is not suggested that no attempt was made to prevent air from leaking into the condenser, but with engines working under moderate loads with both intermediate- and low-pressure steam chests at pressures below atmospheric, even with special attention to piston rod packing, admission of air to the cylinders was almost impossible to prevent. At all events an inspection of records of hotwell temperatures and vacuum under sea conditions in those early days will show conclusively that the temperature was well below the saturation temperature corresponding to the total pressure in the condenser.

The first set of systematic experiments upon surface condensers, of which I know, was carried out at Newcastle by Professor Weighton, using the engine plant to which I made previous reference. A description of the tests will be found in his paper presented to the Institution of Naval Architects in 1906. The experiments were made to show the performance of condensers with what were novel features of design at that period. Thus the water of condensation was removed from the tube spaces at several stages of the condensation process; the usual steam space at the top of the condenser was removed and in its place was substituted a passage of shape and section designed to distribute the entering steam over the whole length of the tubes; the section of the condenser was so proportioned as to promote uniformity of steam flow over the whole tube surface. The tests were made of special interest by comparing the performance of the new design of condenser with that of the condenser originally supplied with the engine. This followed the conventional design features of marine condensers of those days and was a fair representation of standard practice.

This paper is well worthy of detailed study as it touches upon most of the points discussed even in modern papers upon condensing plant. The most striking feature disclosed by the tests was that the new type of condenser with 62 square feet of surface was capable of maintaining the same vacuum under similar steam conditions as the old condenser with 170 square feet of surface. The amount of circulating water used with the new type was also appreciably reduced since it was found possible to hold the same vacuum with a higher outlet temperature of circulating water. In all tests air leakage was reduced to a minimum and the same air pump was used for both old and new types of condenser.

Since the publication of this paper much greater attention has been given to condenser design and, especially in marine installations, great savings of weight and space have been made. The reduction in cooling surface must not, however, be attributed to any magical changes in the laws of condensation of steam but rather to the fact that the steam as it passes through the condenser is persuaded to come into contact with all of the cooling surface, so that large "dead" spaces are no longer possible.

Vacuum and Efficiency.—When once attention had been directed towards the pernicious influence of air in the condenser, greater care was given to the means of minimising its entry and of extracting it, and vacuum production was placed upon a much more scientific basis. One of those most prominent in bringing about this improvement was the late Mr. D. B. Morison, and in a paper he presented to the Institution of Naval Architects in 1908 the phenomena associated with air and vapour mixtures and the means for minimising the evils of inevitable air admission to the condenser were presented in a masterly fashion. Mr. Morison especially favoured the working of marine engines at as high a degree of vacuum as possible and was at some pains to show that with the proper utilisation of exhaust steam from auxiliaries the temperature of the feed water could be brought up to a much higher figure than was usual at that time, even with the engine working at a vacuum between 28in. and 29in. of mercury. In a paper presented to the North-East Coast Institution of Engineers and Shipbuilders (1910–11) he produced many examples of steam engines with suitably designed and proportioned low-pressure cylinder passages, trials upon which had shown that the engine power increased and the steam consumption per brake horse-power decreased as the vacuum rose to the highest figure that could be reasonably carried in a steamship.

(To be continued)

The Mechanism of Magnetisation

By T. F. WALL, D.Sc.*

No. I

THE phenomenon of the ferromagnetism of metals and alloys and its practical applications in dynamo machinery, transformers, instruments, and apparatus, forms the foundation of modern electrical engineering in all its ramifications. In view of the immense practical significance of magnetism, it might have been expected that the relationship between the magnetic quality and the constitution and physical characteristics of the more commonly used magnetic materials would have been exhaustively investigated and a comprehensive survey of the mechanism of magnetisation worked out as a primary essential for a satisfactory electrical engineering technique. It is, however, a remarkable fact that, whilst an immense amount of experimental work has been carried out with regard to individual characteristics of magnetic materials, a comprehensive and systematic survey of the foundation basis of magnetism and the dependence of magnetic quality on the chemical constitution and physical characteristics has made very little progress until the last few years.

The reasons for this unsatisfactory stage of the scientific account of magnetic phenomena may be looked for in the first place in the extremely difficult nature of the problem of explaining and linking up the various aspects of the fundamental fact of magnetism itself, and, in the second place, in the realisation that the experimental work on magnetism has been to a great extent carried out independently of the work on the metallurgical and physical aspects of the characteristics of magnetic materials.

Probably the most notable individual contribution to the modern views of the theory of magnetisation was the conception of the magnetic "domain" by P. Weiss, who was formerly a student of Curie, and, of course, Curie himself had carried out basic investigations on the relationship between paramagnetic quality and temperature. A satisfactory scientific account of the formation of the Weiss domains, however, was not forthcoming until Heisenberg's deduction from his investigations in quantum mechanics, of the existence of "exchange" (*i.e.*, peculiar electrostatic) forces which gave rise to the parallel arrangement of the unbalanced electron spins in neighbouring atoms of ferromagnetic materials.

The requisite technical characteristics of ferromagnetic materials vary enormously, according to the particular purposes for which they are required. Since 1918 there has been extraordinarily keen activity in regard to research and development of magnetic materials, and there can be little doubt that one of the most important consequences of this intensive work has been the rapid progress during the last two decades in all branches of electrical engineering. Modern electrical engineering is dominated by the quality of the magnetic materials which are available, and for this reason no research work in electrical engineering can be more fundamental than that which is concerned with the mechanism of magnetisation.

The quality of magnetic materials is not, of course, merely a question of chemical composition, and the recognition of the cardinal significance of the mechanical and physical conditions of these materials has been largely responsible for the astonishingly rapid development of magnetic materials of the most diverse characteristics for the multitude of applications for which they are required.

Although there is a great deal which is still obscure, it may be said that it is now possible to form a tolerably clear idea of the physical processes involved in the mechanism of magnetisation, and an attempt is made in this article to state the main outlines of the modern views of this mechanism. In the first part of the article a recapitulation of the classical conception of magnetisation with special reference to self-demagnetising effects is given briefly, as well as the main experimental facts which are necessary for a clear understanding of the rest of the article. In the second and third parts the modern views are expounded of the mechanism of magnetisation as based on the theory of the Weiss domains and the Barkhausen Effect, and the controlling influence which is exercised by magneto-striction in determining the magnetic characteristics of magnetic materials. The fourth part of the article is concerned with a record of systematic experiments which have been carried out on iron wire and also on iron and steel tubes. As one consequence of the results obtained in these experiments, a new viewpoint has been reached with regard to the mechanism of magnetisation, and this has led to the conclusion that one aspect of the classical conception of magnetisation is incorrect, and, further, that one group of the experimental results is difficult to reconcile with the simple Weiss domain theory of magnetisation as developed in the second and third parts of the article.

* Department of Electrical Engineering, Sheffield University.

PART I

§ 1. *Definitions.*—If an air-core solenoid, of which the ratio of length to diameter is large, is excited by D.C., the intensity of the magnetic field which is so produced will be uniform over the central portion of the solenoid core and the value of the magnetic force, expressed in oersted, is denoted by the symbol H. If, now, an iron wire is placed centrally in this uniform field then, apart from the self-demagnetising effect of the free magnetic poles at and near the ends of the magnetised wire as is explained in some detail in § 2, it is in accordance with the classical conception of magnetisation to assume that the magnetising force H within the iron wire will have the same value as will exist in the solenoid core when the iron wire has been removed. In other words, the magnetic intensity H of the magnetic force throughout the space occupied by the wire is unaffected by the presence of the iron wire.

It is also in accordance with the classical conception of magnetisation to assume that the intensity of magnetisation J (that is, the magnetic moment of the material per unit volume) in a homogeneous wire, due to the magnetising force H, will be of uniform value throughout any cross section at right angles to the axis of the wire. The intensity of magnetisation when multiplied by 4π, viz., $4\pi J$, is sometimes referred to as the "metallic magnetic density" to distinguish it from the total induction density B.

The total induction density B, or more briefly expressed, the magnetic induction in the wire, is related to the intensity J and to the magnetising force H by the expression:

$$B=H+4\pi J \quad . \quad . \quad . \quad . \quad (1)$$

where B is measured in gauss and is assumed to be uniform throughout any cross section taken at right angles to the axis of the wire.

The permeability μ of the wire at any place at which the induction is B and the magnetic force is H will be given by the expression:

$$\mu=\frac{B}{H}$$

The susceptibility κ is defined by the expression

$$\kappa=\frac{J}{H} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

so that

$$\mu=\frac{B}{H}=\frac{H+4\pi J}{H}=1+4\pi\kappa,$$

or

$$\kappa=\frac{\mu-1}{4\pi} \quad . \quad . \quad . \quad . \quad (3)$$

The strength of a magnetic pole or magnetic mass is defined by the mechanical force which exists between two such poles as is expressed by Coulomb's law of inverse squares, viz.:

$$F=\frac{m\,.\,m'}{\mu\,.\,d^2}\ \text{dynes} \quad . \quad . \quad . \quad (4)$$

where m is the strength of one pole and m' is the strength of the other pole, each pole being assumed to be concentrated at a point. The distance between the two poles is d cm. and μ is the magnetic permeability of the medium in which the poles are placed. For open space, the permeability is $\mu=1$. It is seen from this definition that when a magnetic pole of unit strength is placed at a distance of 1 cm. from a pole of equal strength in air or a vacuum, the force acting between the two poles will be 1 dyne (981 dynes = 1 gramme, and 1 kilo. = 1000 grammes = 2·2 lb.).

§ 2. *The Self-demagnetising Effect of a Magnetised Wire or Rod.*—When it is required to investigate the magnetic properties of ferromagnetic specimens which are in the form of straight rods or wires, and particularly for materials of high permeability, the most satisfactory method is to place the specimen in a long air-core solenoid, the excitation of which by means of D.C. provides the magnetising force H. With such an arrangement there will be developed free poles at and near the ends of the specimen, and these poles will in general give rise to a "self-demagnetising effect" on the specimen. This effect may be defined by means of a self-demagnetising factor Y as follows.

Let H′ be the intensity of the magnetising field due to the excitation of the solenoid—that is, the field which would be established in the core of the solenoid if the specimen were to be removed. Further, let H be the actual value of the intensity of the magnetic force at the middle of the specimen when in position in the excited solenoid; then

$$H=H'-Y\,J;$$

that is

$$Y=4\pi\frac{H'-H}{B-H} \quad . \quad . \quad . \quad . \quad (5)$$

For the special case of a permanent magnet the value of H′ will, of course, be zero, so that the self-demagnetising factor Y will then be given by the expression

$$Y=4\pi\frac{H}{B-H}$$

The value of the factor Y is dependent upon the dimensions of the specimen. The greater the ratio of the length to the diameter of a rod specimen, the smaller will be the self-demagnetising factor Y. For the extreme case of a very short specimen, such as a thin disc which is magnetised in the direction of its axis, the value of the self-demagnetising factor is $Y=4\pi$. For a closed ring specimen there will be no free magnetic poles and in this case the self-demagnetising factor Y will be zero.

It is possible to calculate with great accuracy the value of the factor Y for the case of an ellipsoid of revolution in terms of the ratio a/b, where a is the half-length of the major axis and b is the half-length of the minor axis. When the ellipsoid is formed by the rotation of an ellipse about its major axis $2a$ the value of the self-demagnetising factor is found to be given by the expression[1]

$$Y=\frac{4\pi}{p^2}\left\{\frac{1}{2\,\Sigma^3}\log_e\left(\frac{1+\Sigma}{1-\Sigma}\right)-\frac{1}{\Sigma^2}\right\} \quad . \quad . \quad . \quad . \quad (6)$$

where $\Sigma=\sqrt{1-1/p^2}$ is the eccentricity and $p=a/b$ the dimension ratio of the ellipsoid. This expression may be more conveniently written

$$Y=\frac{4\pi}{p^2-1}\left\{\frac{p}{\sqrt{p^2-1}}\log_e\left(p+\sqrt{p^2-1}\right)-1\right\} \quad . \quad (7)$$

and this result holds when the ratio p is greater than unity.

When the ratio p is very large the expression for the self-magnetising factor reduces to the simple form

$$Y=\frac{4\pi}{p^2}\left\{\log_e 2\,p-1\right\} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

When the ratio p is less than unity, the expression for the self-demagnetising factor becomes

$$Y=\frac{4\pi}{1-p^2}\left\{1-\frac{p}{\sqrt{1-p^2}}\cos^{-1}p\right\} \quad . \quad (9)$$

Since the foregoing considerations lead to the conclusion that the magnetisation, the intensity of the magnetic force and the self-demagnetising factor throughout the ellipsoid are constant, and further, since the self-demagnetising factor is independent of the permeability, the ellipsoid of revolution has been looked upon as a particularly suitable form of specimen for purposes of magnetic tests in cases when ring specimens are otherwise unsuitable.

The ellipsoid of revolution presents no particular practical difficulty to prepare, but it does take time and is relatively expensive, so that for general purposes a cylindrical form of rod or a wire is much more convenient.

The use of cylindrical rods or specimens of rectangular cross section involves the careful consideration of the self-demagnetising effect of the ends, and C. G. Lamb has shown[2] that the induction in a long bar which is magnetised by means of a solenoid not only varies considerably along its length, but that the nature of this variation is greatly

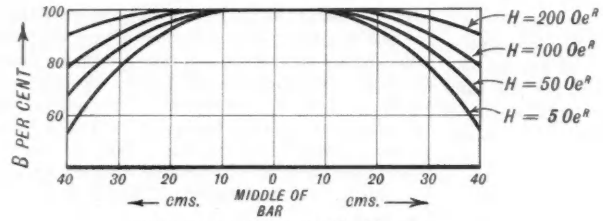
[1] See also K. Warmuth, "Archiv für Elektrotechnik," Vol. XXX, 1936, page 761.

[2] *Phil. Mag.*, 1899, Vol. XLVIII, page 262.

influenced by the permeability, and consequently by the degree of saturation to which it is magnetised. For example, in Fig. 1[3] is shown the variation of the induction in a bar as a function of the distance from the ends and also as a function of the strength of the magnetising force. The dimension ratio of this bar was $p=45$ and the length 100·4 cm. The bar was magnetised in a solenoid of length 140 cm. and was so dimensioned that the magnetic field strength due to the exciting current was quite uniform over a length of 80 cm., whilst over a length of 105 cm. the departure from uniformity was less than 1 per cent.

Many attempts have been made to develop formulæ by means of which the demagnetising factor Y may be calculated from the dimensions of the specimen and its permeability and one of the most successful of these appears to be that due to Stablein and Schlechtweg.[4] For practical purposes the application of this formula is much facilitated by the use of the series of curves given in Fig. 2.

As an example of the application may be taken the case of a cylindrical rod of steel, 48in. long and 2·25 square centimetres cross section, giving a dimension ratio of $p=72$. The magnetisation curve as obtained ballistically by means of a search coil wound round the central portion is shown in Fig. 3. In Fig. 4 is shown the calculated value of the true magnetising force at the middle



SOFT IRON BAR: LENGTH=80 cms.
DIMENSION RATIO: p=45
FIG. 1

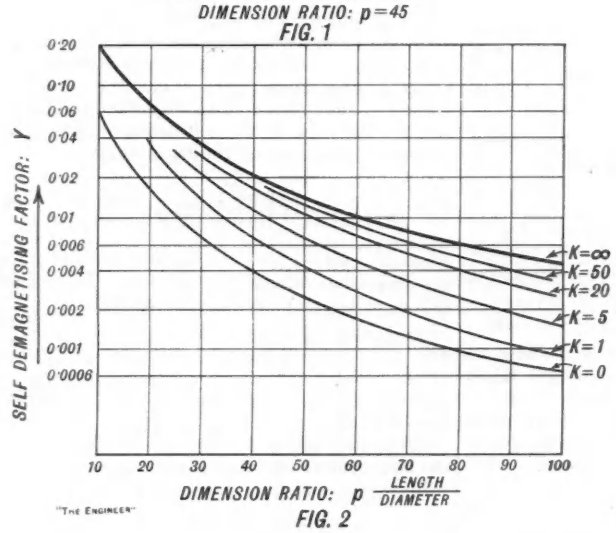


FIG. 2

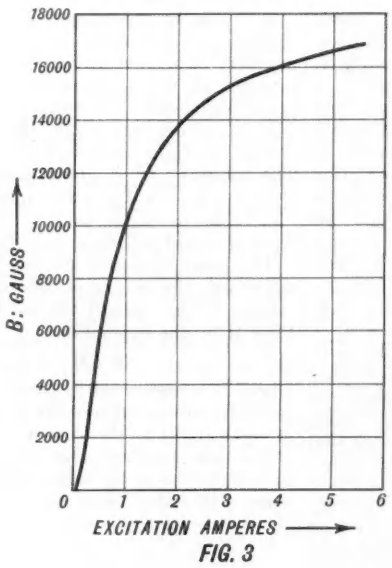


FIG. 3

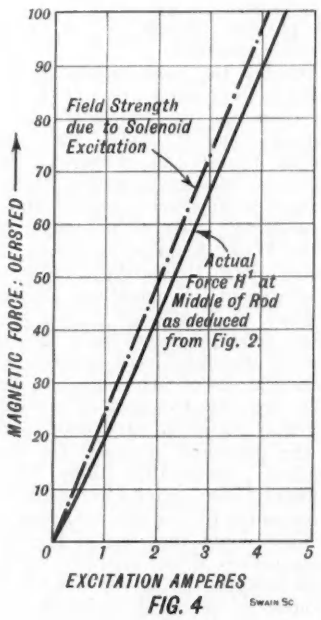


FIG. 4

of the rod plotted as a function of the magnetising current. In the same Fig. 4 is also shown the values of the magnetising force due to the solenoid winding when the specimen has been removed, the difference between the two values giving the amount by which the magnetising force is reduced on account of the self-demagnetising effects of the ends of the specimen.

Experimental data recorded by K. Warmuth[5] show that for cylindrical rods with a range of values for the dimension ratio from 10 to 45, the agreement between the values calculated from the formula of Stablein and Schlechtweg and those obtained by ballistic measurements is very close.

§ 3. *The Magnetisation Characteristics.*—In Fig. 5 is shown a typical magnetisation curve as obtained from ballistic measurements by the method of reversals, and gives the relationship between the magnetising force H and the corresponding values of the induction density B. It is assumed that the values of B have been corrected for any self-demagnetising force in accordance with the methods which have been explained in § 2.

For many purposes it is more convenient to draw the magnetisation curve with the values of the intensity of magnetisation J as ordinates instead of the induction density B, it having already been stated in § 1 that the relationship between J and B is given by the expression

$$B=H+4\pi J.$$

For large values of the magnetising force H the intensity of magnetisation J approaches a limiting value, which is termed the saturation intensity, and is shown in Fig. 6.

The curve O C K in Fig. 5 is sometimes termed the "null magnetisation curve" to denote that it passes through the origin O (see also Fig. 7). The saturation intensity J_s is also known as the "technical saturation intensity" to distinguish it from the so-called "true magnetisation intensity" of P. Weiss, to which further reference is made in § 4.

The initial permeability μ_o is given by the slope of the magnetisation curve at the origin, that is, in Fig. 7, $\mu_o=\tan\theta_o$. The maximum permeability μ_{max} is given by the slope of the line O A in Fig. 7, which passes through the origin and is tangential to the magnetisation curve at C, so that

$$\mu_{max}=\tan\theta_{max} \quad \text{The quantity} \quad \left.\frac{d\,B}{d\,H}\right]_{max}=\tan\theta_s$$

is the maximum slope of the magnetisation curve, that is, the slope of the line F G in Fig. 7. This quantity is an important characteristic of the magnetic quality of the material, and further reference to it will be found in Part IV.

In Fig. 8 is shown the hysteresis loop A C D F G K A. To obtain this loop the material has been magnetised according to the null magnetisation curve O A, and the magnetising force then reduced to zero and increased in the opposite direction to the value $O F_1=O A_1$. The values of the intensity of magnetisation J in Fig. 8 are assumed to have been corrected for the self-demagnetising effect.

The value of the intensity when the magnetising force has been reduced to zero, that is, the value corresponding to the point C in Fig. 8, is the "remanent intensity" J_{rem}, and the value of the magnetising force which is necessary to reduce the intensity to zero, viz., O D, is termed the "coercive force" H_c.

The shaded area A L C is a measure of that portion of the energy which has been required to magnetise the specimen to the state defined by the point A and is recoverable when the magnetisation has been reduced to zero. The magnitude of this recoverable energy in ergs per cubic centimetre of the material is given by the expression

$$\int H\,d\,J=(\text{Shaded area A L C}). \quad . \quad (10)$$

The area A C D F G K A which is enclosed by the hysteresis loop is a measure of the energy which is dissipated in heat (and hence irrecoverable), when the magnetisation is carried through one complete cycle. The amount of this irrecoverable energy is given by the expression

$$\left.\begin{array}{l}\text{Energy loss in ergs per cubic centimetre of the material}=(\text{area of the hysteresis loop in J : H units})\\ \text{or}\\ \text{Energy loss in ergs per cubic centimetre of the material}=\dfrac{1}{4\pi}\ (\text{area of the hysteresis loop in B : H units}).\end{array}\right\} \quad . \quad (10a)$$

§ 4. *The Influence of Temperature on Magnetisation.*—It has been known for more than 300 years that if iron is heated to redness it becomes non-magnetic. About seventy years ago, C. Gore showed that when iron is heated to redness, not only does it lose its magnetic properties, but that there are also other striking changes in its specific heat, electric resistance, and other physical properties. About fifty years ago W. F. Barrett discovered the fact that when iron is heated to bright redness and then allowed to cool down to a deep red colour, it suddenly brightens up again as though heat energy had been released within the iron itself. To this sudden brightening the name of "recalescence" was given. Actually the iron does not become entirely non-magnetic when its temperature is raised above a red heat, but it changes from the strongly or "ferro-magnetic" state to the feebly or "paramagnetic" state.

The physical changes which occur at temperatures in the neighbourhood of recalescence have been the subject of a multitude of careful investigations, and an immense amount of experimental data has been accumulated, although the full interpretation of these changes is not yet completely understood. One of the best-known investigators in this realm has been P. Curie, and his name has become permanently identified with this work by the general acceptance of the practice of the use of the term "Curie point" to denote the temperature at which the change of state of a magnetic substance from the ferro-magnetic to the paramagnetic condition occurs.

Curie found that paramagnetic substances have in general an intensity of magnetisation in simple inverse ratio to the absolute temperature when magnetised in a field of constant strength. It is also known that the intensity of magnetisation of paramagnetic substances is directly proportional to the strength of the magnetising force at constant temperature. It follows, therefore, that if J is the intensity of magnetisation, H is the strength of the magnetising field, and T

[3] "Archiv. f. Elek.," *loc. cit.*
[4] *Zeit. f. Physik*, 1935, page 630.
[5] "Archiv. f. Elek., *loc. cit.*

is the absolute temperature—that is, the temperature in degrees Centigrade+273—then

$$J=A\frac{H}{T}$$

or

$$\frac{H}{J}=R'T \quad . \quad . \quad . \quad . \quad . \quad (11)$$

where $R'=\frac{1}{A}$ that is, the reciprocal of Curie's constant A.

It is to be observed that the manner in which the intensity of magnetisation varies in relation to the field strength and temperature is analogous to the manner in which the density of a gas varies under the influence of pressure and temperature respectively. Thus, the magnetic intensity J corresponds to the density ρ of the gas; the magnetic force H corresponds to the pressure p applied to the gas, whilst the absolute temperature T plays the same part in both cases.

The well-known equation for the gas relationships is

$$\frac{p}{\rho}=RT \quad . \quad . \quad . \quad . \quad . \quad (12)$$

so that the constant R′ in the paramagnetic relationship (11) corresponds to the constant R in the gas equation (12).

Curie concluded that ferromagnetic substances other to give rise to an intrinsic pressure, and (ii) the limiting value of the density of the liquid, so that the equation may be written in the form,

$$(p+p_i)\left(\frac{1}{\rho}-\frac{1}{\rho_o}\right)=RT \quad . \quad . \quad . \quad . \quad (13)$$

where ρ is the density expressed as the reciprocal of the volume.
ρ_o is the limiting value of the density.
p_i is the intrinsic pressure.

In a similar way the extended magnetic equation may be written

$$(H+H_i)\left(\frac{1}{J}-\frac{1}{J_s}\right)=R'T \quad . \quad . \quad . \quad (14)$$

in which H is the magnetising field strength.
H_i is an intrinsic field of the substance.
J_s is the saturation value of the intensity of magnetisation.

The values of the constants for the three ferromagnetic substances, iron, cobalt, and nickel, are given in the following table :—

	Iron	Cobalt	Nickel
Saturation intensity, J	1720	1410	485
Absolute temperature of transformation, T	1041	1388	658
Temperature of transformation in deg. Cent.	768	1115	385
Intensity of intrinsic magnetic field, oersted	23×10^6	38×10^6	26×10^6

It has been found that when exact measurements of the magnetisation are made in very strong fields at temperatures sufficiently far above single crystal of soft iron. A field strength of 500 oersted gave the technical saturation intensity at room temperatures and the falling-off of the intensity J as the temperature increases is shown in Fig. 10. Other curves show the relationship between the intensity J and the temperature for lower values of the magnetising force.

A very interesting effect of temperature on magnetisation is shown in Fig. 11, which gives the values of the initial permeability μ_o for iron as a function of the temperature. It will be seen that the value of μ_o rises only very slowly with increase of temperature until a temperature of about 700 deg. Cent. is reached, after which μ_o rises to a very high value just before the Curie point is reached and then falls to zero with a further increase of a few degrees, becoming practically zero at the Curie point of about 768 deg. Cent.[9]

In Fig. 12 the full-line curve shows a hysteresis loop taken at room temperature, and the broken-line curve a hysteresis loop taken for the same material at a much higher temperature. From these results it will be seen how the increase of temperature causes a reduction of the saturation intensity obtainable, a reduction of the whole hysteresis loop, and a reduction of the permeability at the higher values of the magnetising force.

§ 5. *Magneto-Striction.*—The interdependence of mechanical stress and the magnetic characteristics of a substance has long been recognised as one of immense fundamental significance. Joule appears

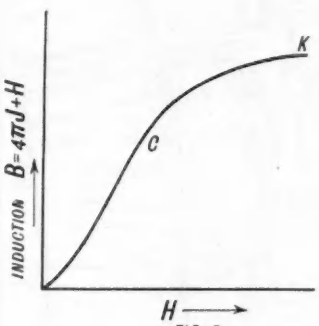


FIG. 5

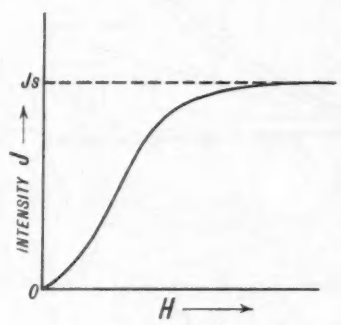


FIG. 6

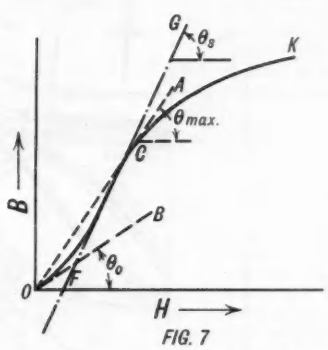


FIG. 7

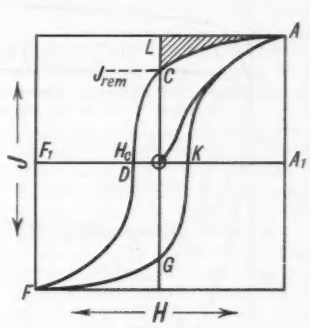


FIG. 8

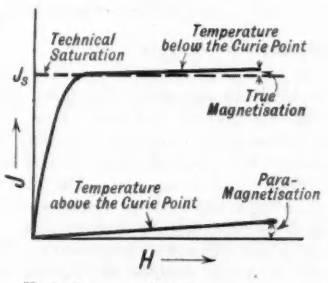


FIG. 9

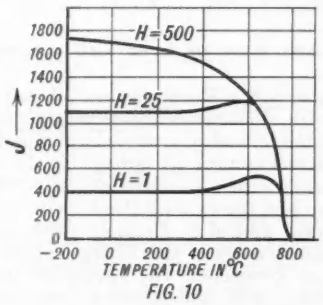


FIG. 10

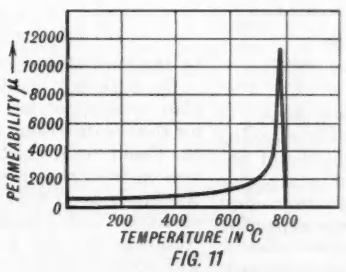


FIG. 11

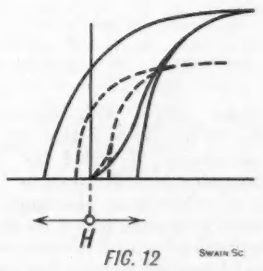


FIG. 12 SWAIN Sc.

are progressively transformed when heated, and tend to assume the properties of feebly magnetic substances as the temperature is raised through the transformation point. He pointed out that there is a close analogy between (i) the curves of intensity of magnetisation in a constant field as a substance changes from a ferromagnetic state to a paramagnetic state with the rise of temperature; and (ii) the curves of density of a liquid at constant pressure as it passes to the gaseous state when the temperature is raised.

The possibility of arriving at a general equation for magnetism to include both the ferromagnetic and the paramagnetic states and analogous to the general equation of Van der Waals, which includes both the liquid and the gaseous states, was suggested by the following facts,[6] viz.:—

(*a*) The correspondence between the laws of gases and the laws of paramagnetic substances; (*b*) continuity of the gaseous and the liquid states, as established by Andrews; (*c*) the continuity of the paramagnetic and ferromagnetic substances, as established by Curie; (*d*) the fact that the density of a liquid and the intensity of a ferromagnetic substance each tends to a limiting value.

The salient facts embodied by Van der Waals in his equation which approximately represents the properties of a fluid are :—

(i) The reaction of the gas molecules on each and far below the Curie point, there is a continuous increase of magnetisation, and this increase shows a linear proportionality for field strengths up to about 10,000 to 30,000 oersted as is indicated in Fig. 9. This magnetisation has been termed by Weiss "true magnetisation" in contradistinction to the "technical magnetisation" for which the saturation value J_s is the final limiting value. The magnitude of the true magnetisation in the neighbourhood of the Curie point and in field strengths up to about 2000 oersted reaches values which are comparable with the technical magnetisation at these temperatures. Further, there is good reason to believe that in field strengths which are greater than about 10^6 oersted the same absolute saturation intensity will be reached at all temperatures.[7]

In the case of hard magnetic materials, intense magnetic field strengths are necessary to reach the technical saturation J_s. As far as is at present known, however, the true magnetisation intensity is independent of the hardness of the material.

The intensity of magnetisation which is obtainable in a magnetic material depends upon the temperature. As the temperature rises the intensity of magnetisation falls, at first slowly, and then very quickly at higher temperatures. In Fig. 10, for example, are shown the results of measurements made by Honda, Masumoto, and Kaya[8] on a to have been the first to observe that a bar of iron changes in length when magnetised, and this change in length is sometimes referred to as the "Joule Effect." It was, however, Shelford Bidwell[10] who first carried out a systematic series of exact investigations of this phenomena, and these researches have become classical.

Under the term "magneto-striction" is understood the change of dimensions of ferromagnetic substances when placed in a magnetising field, and includes not only the change in length, but also the simultaneous change in cross section. In Fig. 13 are shown the changes in length per unit length—that is,

$$\frac{\Delta l}{l}$$

for the ferromagnetic metals iron, cobalt, and nickel, as a function of the magnetising field strength. It will be seen that iron increases in length when subject to small and moderately strong magnetising forces, but decreases in length when subject to strong magnetising fields. For one value of the field strength there is no change in length, and this point on the curve in Fig. 13 is known as the "Villari point." The reversal of sign of the magneto-striction effect as the field strength is increased through this critical value is known as the "Villari reversal."

Cobalt has the peculiar characteristic that when

[6] See "Ferromagnetism," by J. R. Ashworth, D.Sc. (Francis Taylor).

[7] W. Gerlach, "Probleme der Technischen Magnetisierungskurve."

[8] Science Rep. Tohoku Imp. Univ., Vol. 17, 1928.

[9] See also D. K. Morris, *Phil. Mag.*, 1897.

[10] Proc., Royal Society, Vol. XL, 1886, Vol. XLVII, 1890.

in the cast condition it decreases in length for weak fields and moderately strong fields, and increases in length for very strong fields. When annealed, however, cobalt decreases in length for all values of the magnetising field strength; that is to say, there is no Villari reversal for this condition.

Nickel decreases in length for all values of the magnetising field strength, and these changes in length are very much greater for nickel than for either of the other two ferromagnetic metals.

In Fig. 14 are shown the changes in length of

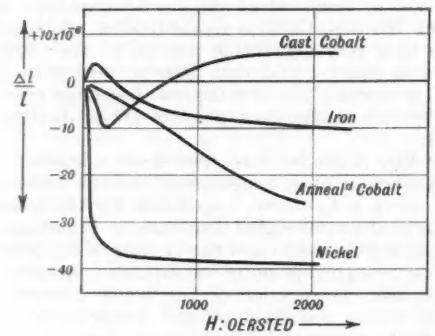


FIG. 13

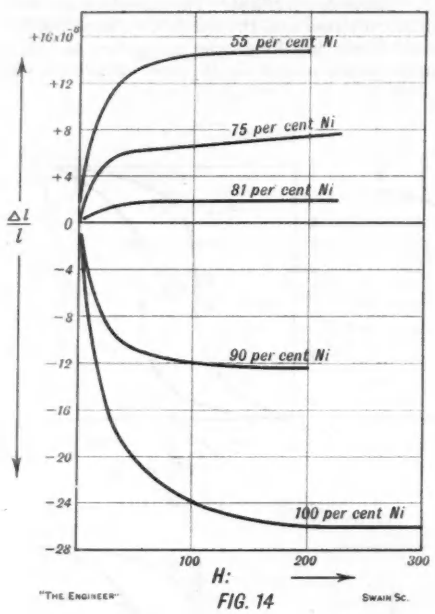


FIG. 14

iron-nickel alloys with various percentages of nickel. It will be seen that by suitably choosing the percentage of nickel the magnitude of the magneto-striction effect can be varied over a wide range of values from the large contraction effect obtained with pure nickel to the large expansion effect obtained with a 55 per cent. nickel alloy.

The change of volume due to magnetisation is very small for nickel, iron, and cobalt, but relatively very large for the iron-nickel alloys.

The effect on the magnetic characteristic of iron

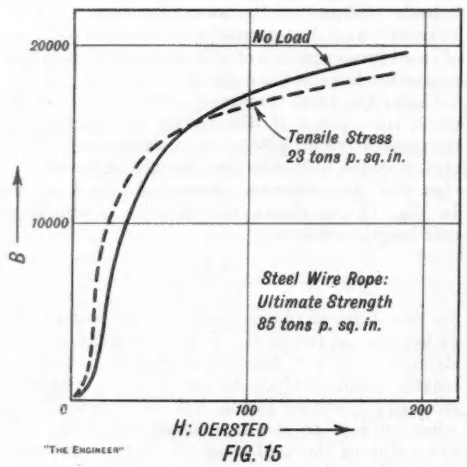


FIG. 15

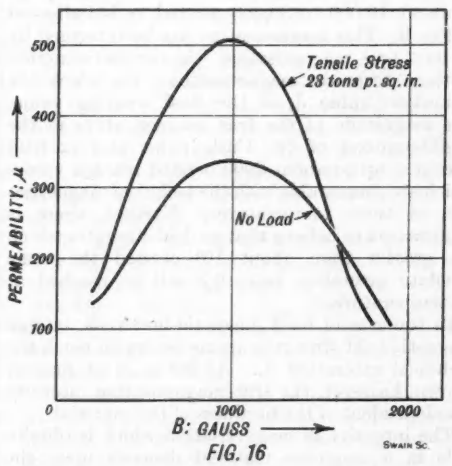


FIG. 16

when loaded was observed by Villari, and Sanford[11] carried out a series of tests for the case of a steel wire. These tests showed that for a load less than about 25 tons per square inch the effect on the permeability due to loading was negligible. The respective magnetisation curves are given in Fig. 15, from which it will be seen that for values of the magnetising force which are less than about 70 oersted, loading the wire increases the magnetic permeability, whereas for values of the magnetising force which are greater than about 70 oersted loading the wire reduces the permeability. In Fig. 16 the permeabilities of the loaded and unloaded wire respectively are shown as a function of the induction density B.

A ballistic method for measuring the nature of the effect on the permeability of iron and steel wire due to loading has been described in a previous article.[12]

(To be continued)

[11] Villari: Pogg. Ann., 1865. Scientific Papers of the Bureau of Standards, No. 496, 1924.

The Auto-Route de l'Ouest

BEFORE 1935 the exits from Paris to Normandy and Brittany, via St. Germain, St. Cloud, and Rocquencourt or Versailles, were all of a winding nature, and the width of the roadways was insufficient for modern through motor traffic. Hence delays occurred and it took a long time to get out of Paris in a westerly direction. The most direct route was that crossing the Seine from Boulogne by the old bridge of St. Cloud and then proceeding through the town of St. Cloud by Route Nationale No. 307 round the hill surmounted by the Park of St. Cloud, and on to Rocquencourt.

By a Decree of May 4th, 1935, a preliminary plan was approved by the French Government for the construction of a trunk motor road through St. Cloud to Rocquencourt, with a northern extension from that point to join the existing Route Nationale No. 190 at a point west of St. Germain-en-Laye; and a southern extension to join Route Nationale No. 10 west of Versailles. The work was actually begun in July, 1936, and is still in hand.

The old bridge at St. Cloud was very narrow and the scheme included its reconstruction with a much more direct route with a flatter inclination. The park is situated on a plateau with a steep slope on the side next to the Seine, and a gentle slope on the westward side, where the general level of the land is much higher than in the part adjoining the river. The lay-out of this part of the auto-route is shown in the plan, Fig. 1.

The reconstruction of the bridge is illustrated in the engraving, Fig. 2, which shows the stage it had reached in July, 1939. The new bridge is a steel plate-girder bridge, the steelwork being

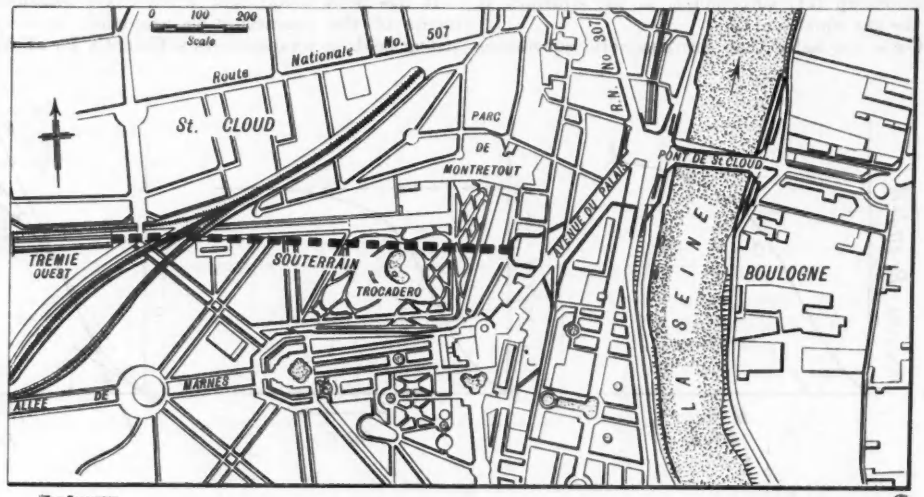


FIG. 1—SITE PLAN OF ROAD AND TUNNEL THROUGH ST. CLOUD

electrically welded throughout. The main girders are carried on reinforced concrete cross beams supported by reinforced concrete cylinders sunk in the river bed. The general design of the bridge is a simple and economical one. On the west side some buildings have been removed and a large open area formed, with a central plot, to be known as the Place Georges Clemenceau. From this square the existing Avenue du Palais, which leads up an incline to the park, has been widened as far as the entrance of the tunnel, forming a new boulevard 131ft. wide; and a large open space has been formed in front of the east portal of the tunnel as shown in Fig. 1.

The tunnel, a cross section of which is shown in Fig. 3, inclines upwards from east to west and has a total length of 2729ft. The width is 55ft. 9in. at the road level, of which the carriageway occupies 49ft. 2in. The height above the roadway at the centre of the arch is 21ft. 4in. The floor and abutments are of concrete and the arch of masonry. The thickness of the floor is 1ft. 7½in., and of the arch, in the centre, 3ft. 9in, whilst the abutments are 9ft. 2in. thick.

The tunnel was driven through limestone, the mode of construction being to drive three top headings, one in the centre, and one at each side. The abutments were first formed by sinking from the side headings in alternate bays, the intermediate bays being taken out when the first had been concreted. Traverses were then cut between the side and centre headings and centering for the roof was then fixed in them and the masonry built. The struts were relieved as the masonry proceeded, the side and top sheeting being left in position. The dumpling was not excavated until the abutments and roof had been completed; and finally the floor was concreted. At some points difficulties were occasioned by old quarries, and special works were involved, piers 6ft. 6in. square being carried down to the quarry floor and relieving arches turned over the main arch.

On page 280 are shown views of the eastern

roadway width of 88ft. 6½in. and two footways of 16ft. 5in. each.

The expense of acquiring property for the construction of a wide road through the town of St. Cloud would have been so great that it was decided to drive a tunnel beneath the park of St. Cloud instead, particularly as this scheme afforded a

[12] THE ENGINEER, September 13th, 1935.

and western portals, respectively, in July, 1939. The tunnel will be lighted throughout and mechanically ventilated. At the west end of the tunnel the road rises in a "tremie" or open cut with brick-faced retaining walls, see page 280. It emerges at the general level of the new road, at a point just beyond the outskirts of the town of St. Cloud.

The new main trunk road from this point to the point where it separates, at Rocquencourt, into the new northern and southern branch roads, has a total width at formation level of 98ft. 5in. There are two footways with a width of 9ft. 4in., two carriageways with a width of 29ft. 6in., and a central reserve 8ft. 2¼in. wide.

The road formation runs in the Fontainebleau sand for the greater part of its length. The whole of the formation was excavated or filled, graded, and drained many months before any surfacing was applied, so as to allow for the correction of any possible subsidences or slips well in advance.

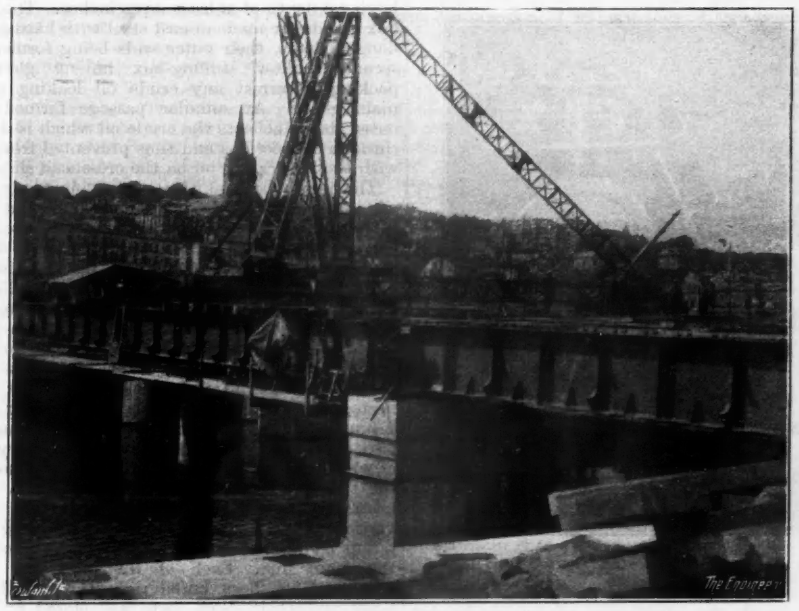


FIG. 2—NEW BRIDGE OVER THE SEINE AT ST. CLOUD—JULY, 1939

On page 280 are shown parts of the formation near Vaucresson with junction roads sloping up at the sides to join an intersecting road carried on an overbridge. There are no crossings on the level, either in the main trunk or branch roads; but there are a large number of reinforced concrete over and underbridges.

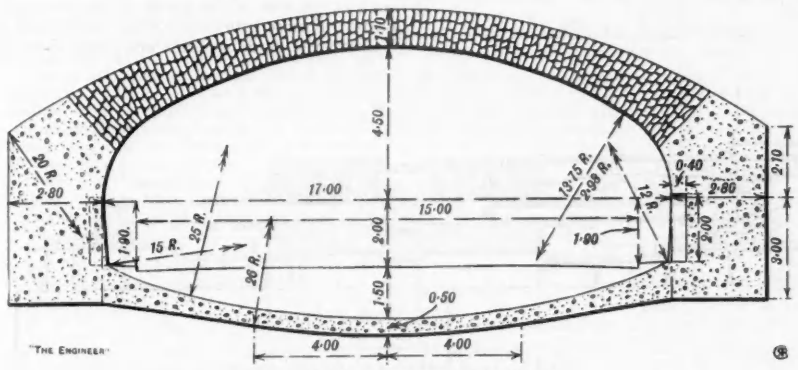


FIG. 3—CROSS SECTION OF TUNNEL

In Fig. 4 is reproduced a view of a model of the connections between the main trunk road and the northern and southern branches at the triangle of Rocquencourt. It will be seen that the design provides for smooth interchange between the main trunk road and the branches, between one branch and the other, and also between the auto-route and intersecting roads, without any junctions on the level.

FIG. 4—ROCQUENCOURT TRIANGLE

The northern and southern branches beyond this point have a formation width of 78ft. 8½in., with two footways each 8ft. 1¼in. wide, two carriageways each 23ft. wide, and a central reserve 4ft. 1in. wide. Both the main trunk and the branch roads are designed with a minimum horizontal radius for curves of 3280ft., and with maximum inclinations of 5 per cent. At the top of inclinations the vertical curvature is of 16,400ft. radius, which ensures a visibility of 820ft. for drivers. This figure is much in excess of that usually provided in this country, namely, 500ft.

The total length of the auto-route is 18·64 miles and the total excavation involved, including that for the tunnel, was 2,616,000 cubic yards.

We wish to acknowledge the kindness of Monsieur de Buffevent, Ingénieur des Ponts et Chaussées, the engineer for the work, in furnishing information and drawings, &c. in connection with this article.

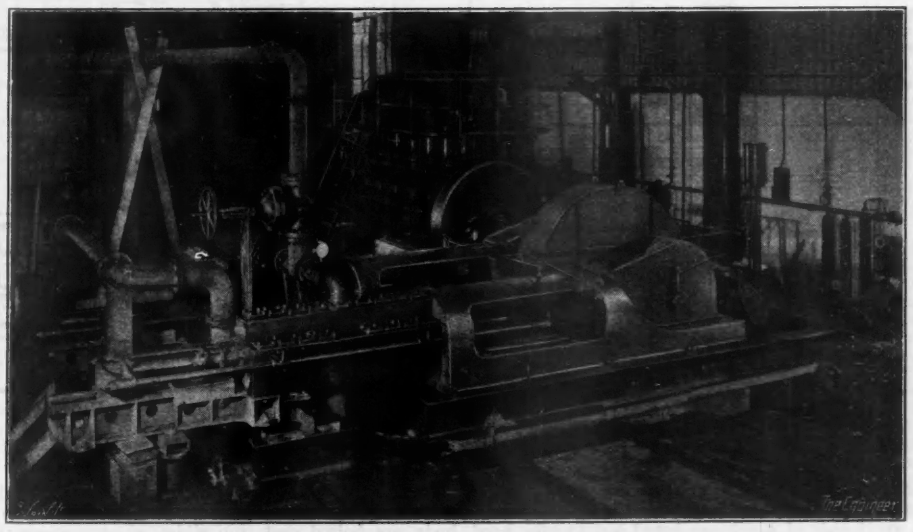
A Large Pipe Line Pump

AT the works of Hayward-Tyler and Co., Ltd., we recently had an opportunity of inspecting on the test bed the first of four large horizontal duplex, double-acting pumps, which are being made for pumping oil in the pipe lines of one of the Shell group of companies in Sarawak and Pladjoe. These pumps are designed to handle 75 cubic metres (16,570 gallons) of crude oil per hour at a pressure of 70 kilogrammes per square centimetre (1000 lb. per square inch). Their construction is particularly massive in order that they may stand up to continuous working over long periods and be capable of withstanding the severe stresses to which they are occasionally subjected in this class of work.

The pump inspected, which is illustrated in the accompanying engravings and drawing, is driven by a vertical gas engine, rated at 275 H.P. at 330 r.p.m., supplied by the National Gas and Oil Engine Company, Ltd. Drive from the engine is transmitted to the pump through a long countershaft which is carried in three oil ring bearings. Two of these bearings are mounted on rearward extensions of the pump bedplate, and the third adjoins a flexible coupling which has been interposed between engine and the countershaft to prevent the transmission of any vibration to the pump. A reduction gear between the countershaft and the pump crankshaft lessens the speed from 330 r.p.m. to 46 r.p.m. This gear was supplied by David Brown and Sons (Hudd.), Ltd., and comprises a 29 toothed pinion on the countershaft driving a 208 toothed wheel on the crankshaft. The wheel has a solid forged steel rim secured to a cast steel rim made in halves held together by bolts and keyed to the pump crankshaft.

As will be seen from the engravings, the pump consists of two separate pumping units driven by a common crankshaft, combined into a rigid complete assembly by heavy cross members designed to resist any twisting movement during working.

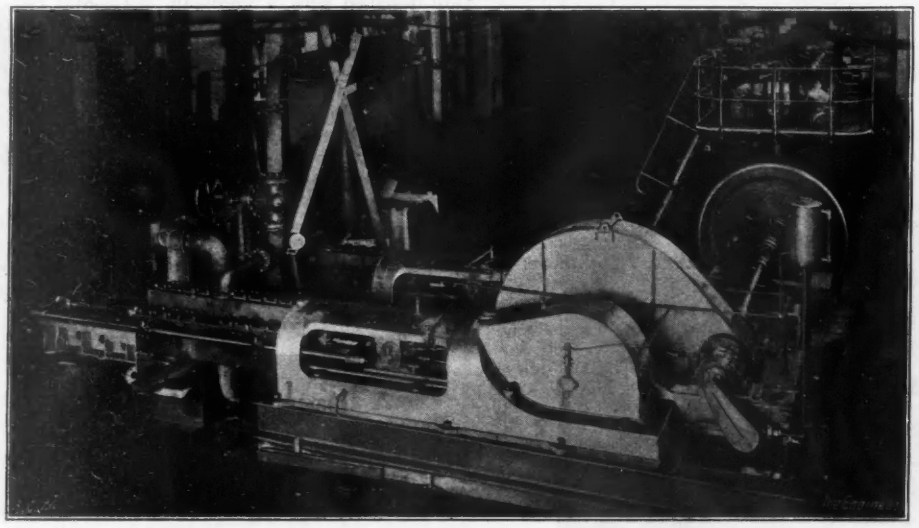
The main casting of each unit incorporates the bedplate, the crosshead guide, a housing for the main crankshaft bearing and the extension to the rear of the bedplate upon which is mounted a countershaft bearing. The guide portion of the casting consists of an open-sided trunk, the inner part of which is accurately bored out to accommodate the crosshead and its front is arranged as a flange on to which the pump body is bolted. True alignment of the two



LARGE PIPE LINE PUMP ON TEST BED

pumping units, when bolted together, is ensured by the machining of the inner side faces of the bedplates and also the corners of the bracing members at the pump end to fit those of the bedplate.

The crankshaft is made of 33/35 tons mild steel, its diameter of 8·5in. being increased to 12·75in. at the middle where the spur wheel of the reduction gear is fitted. It is mounted in heavy cast iron bearings which are lined with white metal and have adjustable steel wedges fitted for the taking up of wear. The crank arms are shrunk and keyed on to the crankshaft at an angle of 90 deg. to each other. Marine type bearings lined with white metal are fitted to the crank pin ends of the forged steel connecting rods, the small ends of which are bored out to take hard bronze bearings, held in position by tapered cotter bolts. The main crossheads are of cast steel and have cast iron shoes accurately turned to fit the bored surfaces of the guide sections. Adjusting nuts and studs are fitted to these shoes, which are designed so that their pressure upon the guide surfaces does not exceed 2 kg. per sq. cm. (28 lb. per sq. in). The main crossheads are cast integral with yokes which project through the open sides of the guide and are connected by side rods to a second crosshead at the other end of the pump body. Plungers for the rear cylinders of the pump body are fixed to the front of the main crossheads.



CRANK END OF PIPE LINE PUMP

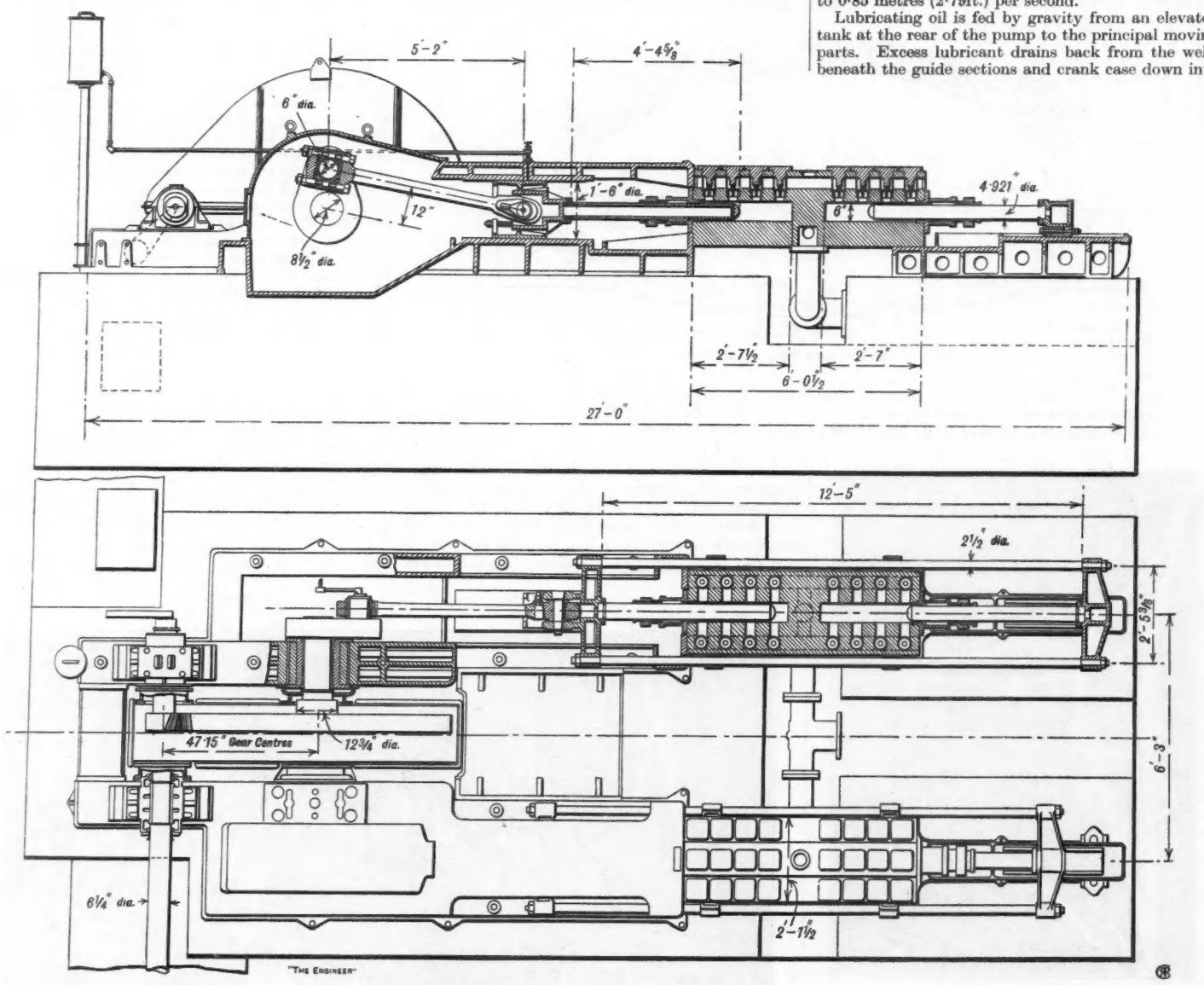
As mentioned previously, the pump bodies are bolted on to the flanges of the guide trunks of the main casting. At the other end of each pump body are bolted cast iron slides which support the second set of crossheads which actuate the plungers for the front cylinders. These second crossheads are cast integral with yokes which are fixed to the side rods from the main crossheads. They have adjustable cast iron shoes which act as rubbers on the supporting slides.

The 4·921in. diameter hollow pump plungers are made of hard polished steel and pass into the cylinders through cast steel stuffing-boxes containing packing having a depth of at least seven inches. The stuffing-box glands are made of cast steel with hard gunmetal flanged liners, their outer ends being formed into a second shallow stuffing-box having glands and packing to arrest any crude oil leaking past the main gland. An annular passage formed on the outer glands collects the crude oil which is drawn off through connections and thus prevented from mixing with the lubricating oil on the crosshead slides.

The pump bodies, which are 72·5in. long, 25·5in. wide, and 23·25in. deep, were machined out of solid forged steel ingots, the cylinders at either end being bored out to a diameter of 6in., 31in. to 31·5in. deep to leave a partition of 10in. of metal between the inner ends. A step 7·375in. wide and 7·825in. deep cut along the side of each body forms a pocket for the 3in. suction valves which are sixteen in number. Each cylinder has eight suction valves, four being placed upon each side. Inlet chambers running the entire length of each side of each body are connected by a central cross passage opening out into a branch of the main inlet pipe which connects the two pump bodies. The eight 3in. delivery valves, of which there are four to a cylinder, are placed along the top of each body. They open into a common chamber which communicates through a short vertical passage to a 4in. branch connecting the two pump bodies and conveying the pumped oil out to the main line. Each of the inlet and delivery chambers has been bored right through the pump body and their dead ends are closed by screwed plugs, the ends of which were sealed by welding.

All the valves are of the mitre wing type made of stainless steel and having springs of the same material. They have been designed to restrict the velocity of liquid through the suction valves to 0·49 metres (1·61ft.) per second, and through the delivery valves to 0·85 metres (2·79ft.) per second.

Lubricating oil is fed by gravity from an elevated tank at the rear of the pump to the principal moving parts. Excess lubricant drains back from the wells beneath the guide sections and crank case down into a small tank below the level of the foundations. From this tank it is pumped up to the gravity feed tank by a small rotary pump driven off the end of the countershaft. We are informed that this pump has now passed the official acceptance tests.



ARRANGEMENT OF LARGE PIPE LINE PUMP

Rail and Road

BELGIAN TRAIN ACCIDENT.—When an express train running between Liege and Tournai recently collided with another from Quievrain to Brussels, near Mons station, twenty-two persons were injured.

ROAD ACCIDENTS IN GREAT BRITAIN.—As a result of road accidents in Great Britain, 416 people lost their lives during the twenty-nine days of February as compared with 463 in the corresponding month of 1939.

SPAIN LINE REOPENED.—The railway service between France and Spain through the province of Huesca was resumed yesterday after having been interrupted since 1936. A banquet was held at Los Aranones station when the first train arrived conveying French and Spanish authorities. The station was decorated with the colours of the two countries.

ROLLING STOCK FOR TURKEY.—A report from Ankara states that the two million pounds worth of rolling stock ordered in this country by Turkey will probably be delivered by the end of this year. The rolling stock, some of which is now arriving in Turkey, will be used for the new railway systems linking Turkey with Persia via Ezerum, and with Iraq via Diarbekir. These systems are now rapidly approaching completion.

RECONSTRUCTION OF HIGHGATE RAILWAY STATION.—The first large contract placed since the war by the London Passenger Transport Board is for the construction of buildings and other works at Highgate Station on the Northern Line. It is part of the work in the extension of the line to High Barnet and in addition to the reconstruction the station is being connected with a new tube station, 135ft. below the road level, by escalators. When completed the station will have five levels.

BRAZILIAN RAILWAY LOANS.—Loans totalling 70,000 contos of reis are to be granted to two British owned railways by the Brazilian Government. The Great Western of Brazil Company is to receive 40,000 contos which will be used in the modernisation and improvement of its line equipment and rolling stock. The Leopoldina Railway will receive 30,000 contos for the equipment of workshops, the purchase of rails and rolling stock, the improvement of signalling and permanent way and the rebuilding of bridges. In both cases the loans are to be advanced in annual instalments of 10,000 contos of reis.

LONDON TRANSPORT.—The draft of the first London Passenger Transport valuation roll, for the Board's transport undertaking, including its railway, tramway, and trolley-bus systems, has been settled and issued by the Railway Assessment Authority. The total net annual value is stated to be £1,765,000, based on the receipts compared with assessments understood to be £1,026,000. The undertaking dealt with by the Authority (including joint lines) extends into seven counties, 91 rating areas (including three county boroughs), and 113 parishes, or other separately or differentially rated areas. The valuation will govern the liability of the Board for local rates from April, 1936, to April, 1941.

INDIAN ROADS.—In the course of his presidential address to the South Indian Roads Congress, Mr. K. G. Mitchell gave some interesting facts about the progress of road work in India. He said that about Rs.235 lakhs has been spent from the Road Fund on providing about 250 new major bridges and causeways together with a large number of culverts and improvements to existing structures, mostly on trunk and main roads. In British India there are now approximately 9000 miles of roads with modern surfaces all provided within the last fifteen years; 38,000 miles of stone metalled roads; 17,000 miles of kankar, moorum, and laterite; 20,000 miles of gravel and other inferior types; and 200,000 miles, or 70 per cent. of the total of 284,000 miles, in nothing better than natural earth.

INDIAN RAILWAY ACCIDENT REPORTS.—During the half year ended September, 1939, there were only four accidents which necessitated inquiry by the Government Inspectors of Railways in India. One was a derailment on the Madras and Southern Mahratta Railway which involved four minor injuries. Another was caused by a collision at a level crossing between a light engine and a motor lorry, between Makarpura and Vishwamitri on the Bombay, Baroda, and Central India Railway. Five people were killed in this accident, for which a gatekeeper was found to be responsible. A more serious accident in which ten were killed and 25 injured occurred when on June 28th, a Delhi–Dehra Dun train ran into a breach between Chandpur Sian and Haldaur on the East Indian Railway. The track supports had been washed away by heavy rain. A derailment owing to a track being weakened in a similar manner occurred on the Katni branch of the Bengal Nagpur Railway on September 7th. Only ten people received minor injuries in this last accident.

THE MERSEY RAILWAY COMPANY.—At the annual meeting of the Mersey Railway Company, the chairman, Mr. J. Waddell, reported that as the Government's terms of compensation for the main line companies were not, in the opinion of the board, applicable to the company for the reason that in March, 1938, the conditions under which the company operated were completely altered by the introduction of the through services of electric trains operated jointly by the Mersey company and the L.M.S. Company. The board had submitted to the Ministry of Transport that the compensation should, as a minimum, be based on the net revenue for the year ended June 30th, 1939, which period was as nearly as possible the first complete year of the changed conditions, and that there should be a commensurate addition for the natural growth of traffic to be realised from the development due to the changed conditions. The Ministry had agreed to a guaranteed minimum net revenue of £100,015 per annum, and that the company should participate in the pool for a proportionate share of any increase in the net revenue beyond the guaranteed minimum.

Miscellanea

FUEL SUPPLY AT BATTERSEA POWER STATION.—In the course of a paper before the Manchester Association of Engineers, Mr. A. Pollitt, of the London Power Company, said that Battersea power station's designed final capacity of 550,000 kW. at 55 per cent. load factor would involve the consumption of 965,000 tons of fuel a year. The storage capacity at the station sufficed for 37 day's average requirements, the coal being principally sea and river borne in colliers.

NEW TURKISH HYDRO-ELECTRIC POWER SCHEME.—It has been announced that a concession has been granted by the Turkish Government for the harnessing of the river Acheloos for the generation of electricity. It involves the construction of an artificial lake at Cremasta to regulate the flow of the river, prevent flooding, and develop irrigation works. Three falls to be formed will be capable of supplying 820 million kWh annually and the power is to be used at metal and chemical works.

SCHEDULE OF RESERVED OCCUPATIONS.—The Ministry of Labour and National Service announces that a new and up-to-date edition of the schedule of Reserved Occupations is now under preparation, and will be placed on sale by H.M. Stationery Office in the course of the next few weeks. Meanwhile, arrangements have been made for the present edition to be withdrawn from sale. Pending the publication of the new edition of the Schedule, information on the subject of the reservation of workpeople may be obtained from any local office of the Ministry of Labour and National Service.

THE COAL COMMISSION.—A capital expenditure of £146,651 is shown in the first accounts of the Coal Commission which cover the period from July 29th, 1938, to March 31st, 1939. It is pointed out in the report that the vesting date on which property in all unworked mines in Great Britain is to pass to the Commission is July 1st, 1942, and that the expenses included in these accounts are all of a preliminary character. The Commission is not yet in possession of revenue-earning assets and all payments were necessarily met by borrowing under the provisions of the Act.

STANDARD ACCEPTANCE CHARTS FOR MACHINE TOOLS.—At a recent luncheon in Leeds, Mr. R. Hazleton of the Institution of Production Engineers said that the national interest called for the earliest possible establishment of standard acceptance charts for machine tools. He went on to say that as agreement on the subject with representatives of the machine tool industry had not yet been found possible, the Institutions of Mechanical and Production Engineers were to publish jointly this month acceptance test charts prepared by the research department of the Institution of Production Engineers.

TIN RESEARCH.—The annual report of the International Tin Research and Development Council describes a new type of electroplating which is hard, pleasing in colour, highly resistant to corrosion, and is expected to compete favourably with chromium. The coating consists of tin and copper in the proportions in which these metals are combined in speculum metal, and its application follows upon the success of research work on the simultaneous electro-deposition of tin and copper in the required proportions. In connection with research on new alloys for bearing metals, three such alloys which possess the best combination of strength, hardness, stability at high temperatures, anti-friction properties, and high melting point are at present undergoing engine tests at the laboratories of the Institution of Automobile Engineers.

HOLIDAYS IN WAR TIME.—The committee on Workers' Holidays set up by the Industrial Welfare Society is of opinion that, in the words of the Amulree Committee, an annual holiday contributes to the workpeople's happiness, health, and efficiency, and that, if the workers are to meet the demands for war time production without undue strain, a holiday, except in sudden or grave emergency, is more vital than in peace time. It also holds that, owing to the use of normal holiday accommodation for various war time purposes, and the limitation on transport by road and rail, it is essential that holidays should be spread over the months of May to October if beneficial holidays are to be enjoyed. The committee therefore appeals to local authorities, employers, and workpeople in the industrial districts, to arrange meetings at an early date to discuss local arrangements for bringing about a spread-over of the holiday period.

THE LATE MR. R. G. SCOTT.—The death occurred in Edinburgh, on February 28th, of Mr. Robert Grigor Scott, at the age of 69, chairman and governing director of MacTaggart, Scott and Co., Ltd., Engineers, Loanhead, Midlothian. Mr. Scott was the eldest son of the late Robert Alexander Scott, Accountant to the British Linen Bank, and with the late Hugh Holmes MacTaggart, son of the late William MacTaggart, R.S.A., founded the firm bearing their name in 1899. Mr. Scott was a former pupil of Allan Glen's School and obtained his early engineering training with Lees Anderson of Anderston, Napier Bros., Ltd., of Glasgow, and Brown Bros. and Co., Ltd., of Edinburgh. Mr. Scott applied himself successfully during the war of 1914–18 to many problems which arose in connection with surface and underwater war vessels. His son, Mr. R. Lyon Scott, has been appointed chairman and governing director of the company.

NEW JAPANESE ALUMINIUM MANUFACTURING PROCESS.—According to a note in the *South African Mining and Engineering Journal*, a new process of manufacturing aluminium, developed at the Tokyo University, is to be put to practical use in a plant being built at Hachinohe, on the Island of Honshu, where ample power is available. The basic material is a phosphorus-bearing alumina (not the usual bauxite) found in Manchuria, and it is treated with sulphuric acid to form aluminium sulphate. This, in turn, is treated with gaseous ammonia at a temperature of 2192 deg. Fah., the products being ammonium sulphate and aluminium oxide. Reduction of the alumina is by the customary electrolytic method. Handling 15,000 tons of ore annually, the plant will have an estimated output of 5100 tons of metallic aluminium, 25,800 tons of ammonium sulphate, and 20,000 tons of fertiliser containing 20 per cent. phosphoric acid, and 16 per cent. ammonium sulphate.

Air and Water

NEW AERODROME IN NORTH DEVON.—A contract valued at a quarter of a million pounds has been placed for the construction of an aerodrome at a site chosen in North Devon.

RAPID SHIPBUILDING IN ITALY.—A report from Italy states that the keel of the 10,000-ton motor ship "Sabastiano Veniero" which has just been launched was only laid five months ago. It is expected that the vessel will make her maiden voyage towards the end of April.

MISSING IMPERIAL AIRWAYS LINER.—Up to the time of writing no traces have been found of the Imperial Airways liner "Hannibal" which has been missing since Friday, March 1st, when on a journey from Calcutta to Alexandria. According to the last message received from the machine she was seeking contact with Sharjah on the Persian Gulf. She was carrying four passengers in addition to her crew of four.

TRANS-TASMAN AIR SERVICE.—The Air Ministry announces that the Governments of the United Kingdom, Australia, and New Zealand have agreed to the commencement of the Trans-Tasman Air Service (on the basis of one service to and from Australia each week) in April when a return flight will be made from Auckland to Sydney by the "Aotearoa." The second flying boat for the service, the "Awarua," is expected to be in New Zealand in the very near future.

UNITED STATES ATLANTIC STEAMER SERVICES.—It is announced that the United States Lines is to resume its North Atlantic services with weekly sailings from Liverpool to New York, calls being made at Manchester, Glasgow, Belfast, and Boston, Mass. A weekly service will also be maintained between New York and the English Channel ports with Antwerp as the terminal call. The ships will sail under the Belgian flag and for the present will be operated on a cargo basis only.

SHIPPING LOSSES.—During the week ended Sunday, March 10th, only five British merchant ships totalling 18,673 tons were sunk as a result of enemy action, and no allied or neutral ships were lost. Up to date about 640,000 tons of British mercantile ships have been sunk as compared with about 300,000 tons of German ships which have been sunk, captured, or scuttled. The German losses are, out of a total of 4 million tons, 7½ per cent. sunk or captured, 25 per cent. bottled up in neutral ports, and the remainder lying idle in home ports.

SWEDISH NAVAL CONSTRUCTION.—The Swedish Parliament is being asked to vote over 63 million kroner for the construction of destroyers, minesweepers, submarines, and other small coastal craft. In view of the urgent need for small naval vessels the construction of two armoured coastal defence ships, for which money was voted last year, is being suspended. It is expected that next year 54 million kroner will be asked for for the construction of warships to replace those now obsolete. Instead of building a mother-ship for submarines, a merchantman is to be bought and reconditioned for the purpose.

A NEW HIGH-SPEED LAUNCH.—A new oil-engine propelled launch recently completed for service in the Far East by the British Power Boat Company, Ltd., is capable of a top speed of 23 knots and a cruising speed of 22 knots when carrying seven people. It has a length of 25ft., a beam of 6ft. 6in., and at rest the draught is 1ft. 9in. From rest the craft can attain full speed in eight seconds and it can be brought from full speed to rest in just over two boat's lengths. The engine is a standard Perkins 130 brake horse power unit and has a forward clutch, reverse gear, electric starting gear, &c. At full throttle the boat has a range of 110 miles and at cruising speed one of 120 miles.

MERSEY DOCK BOARD'S FLOATING PLANT.—At a recent meeting the Mersey Docks and Harbour Board decided to invite tenders for the supply of four grab cranes for two of its barges. These vessels will replace two grab hopper dredgers although the engineer is to endeavour to keep one of them in commission as long as possible. The Board's engineer is also to recondition two other steam hopper barges with a view to keeping them in commission for a further period of two or three years. The existing grab hopper dredger No. 13 is to be replaced by a new vessel. This new ship is to be capable of carrying out the special dredging required, in the restricted space of dock entrances and passages.

GIFT TO R.A.F. BENEVOLENT FUND.—The Air Ministry announces with deep gratitude that Mr. Alexander Duckham has presented Rooks Hill House, a large country house on high ground above Sevenoaks, to the Royal Air Force Benevolent Fund for use as a home for children of personnel of the Royal Air Force who lose their lives while flying. About 200 acres of land go with the house and in addition Mr. Duckham is providing the Benevolent Fund with a substantial sum towards the cost of its maintenance and upkeep. This is the second benefaction which the Fund of the Royal Air Force owes to the munificence of Mr. Duckham. Shortly after the end of the last war he presented a large house (Vanbrugh Castle, Blackheath) for use as a home and school for sons of deceased airmen.

CIVIL AVIATION AND THE BRITISH OVERSEAS AIRWAYS CORPORATION.—In introducing the Air Estimates in the House of Commons, the Air Minister said that a date is to be fixed in the near future upon which Imperial Airways and British Airways will be transferred to the British Overseas Airways Corporation. In succession to Sir John Reith, the Hon. Clive Pearson has been appointed chairman of the Corporation. Mr. Harold Brain and Mr. Gerald d'Erlanger have been appointed members of the Corporation of which the Hon. W. L. Runciman is the chief executive member. In referring to the safeguarding of civil aviation after the war, the Minister said he proposed to set up a Civil Aviation Advisory Committee to keep under review the position of civil aviation in the light of the present situation, and to plan for the future. This committee will have associated with it a small body of experts whose task it would be to keep in close touch with all phases of technical development in the field of civil aviation abroad.

THE AUTO-ROUTE DE L'OUEST, PARIS

(For description see page 273)

EAST PORTAL OF TUNNEL
TRUNK ROAD AT VAUCRESSON

WEST PORTAL OF TUNNEL
TRUNK ROAD AT VAUCRESSON

The Engineer

MARCH 22, 1940

VOL. CLXIX No. 4393

Contents

THE ENGINEER, March 22nd, 1940 PAGE

A SEVEN-DAY JOURNAL ... 269

LEADING ARTICLES—
BRITISH AND GERMAN SCIENCE ... 281
TRAINING IN FOREMANSHIP ... 281
PARIS TRADE FAIR ... 282

SPECIAL ARTICLES—
AUTO-ROUTE DE L'OUEST. (Illus.) ... 276
FIFTY YEARS OF MARINE ENGINEERING. (Illus.) ... 270
INSTITUTION OF NAVAL ARCHITECTS ... 282
MECHANISM OF MAGNETISATION. No. I. (Illus.) ... 273
ROAD OVER RIVER MERSEY AT STOCKPORT. (Illus.) ... 284

AMERICAN RAILWAY BRIDGE AND BUILDING CONVENTION 285
LARGE PIPE LINE PUMP. (Illus.) ... 277
PUMPING SETS FOR OIL FUEL DUTY. (Illus.) ... 289
MOTOR TRANSPORT. No. III. (Illus.) ... 286
TRAFFIC ON PAVED AND UNPAVED ROADS ... 283

LETTERS TO THE EDITOR—
SPECIAL EQUIPMENT AND SMALL FIRMS ... 3

LITERATURE ... 283
BOOKS RECEIVED ... 283

OBITUARY—
WALTER C. MACARTNEY ... 282
W. H. KENNETH FRASER ... 283

NEWS AND NOTES—
AIR AND WATER ... 279
BRITISH PATENT SPECIFICATIONS. (Illus.) ... 291
CANADIAN ENGINEERING NEWS ... 289
FORTHCOMING ENGAGEMENTS ... 292
FRENCH ENGINEERING NOTES ... 291
MARKETS, NOTES AND NEWS ... 290
MISCELLANEA ... 279
RAIL AND ROAD ... 279
SIXTY YEARS AGO ... 289

NOTICES TO READERS

WAR MEASURES

PUBLISHING AND ADVERTISING

THE ENGINEER is now being published at the works of William Clowes and Sons, Ltd., Beccles, Suffolk. Telephone No. Beccles 2103. All correspondence connected with publishing and advertising should be directed to that address.

EDITORIAL

All Editorial correspondence is being conducted from 28, ESSEX STREET, STRAND, W.C.2, and all articles, etc., should normally be sent to that address, but in cases of urgency messages may be sent to the Editor at Beccles.

GENERAL

The head office, 28, ESSEX STREET, STRAND, W.C.2, is open from Mondays to Fridays inclusive from 9-15 a.m. to 5-15 p.m., where classified advertisements may be handed in as usual and copies of the paper may be purchased. The office is not open on Saturdays.

PAPER SUPPLIES

With a view to the conservation of paper, readers are advised, in the interests of all concerned, to place a regular order for THE ENGINEER with their newsagent or direct with the Publisher.

*** *If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

*** *For Subscription rates, see page 2 of Advertisements.*

*** *All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGE OF ADDRESS

*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

Postal Address: "The Engineer," 28, Essex Street, Strand, London, W.C.2.

Telegraphic Address: "Engineer Newspaper, Estrand, London." Telephone: CENtral 6565 (10 lines).

BRITISH AND GERMAN SCIENCE

THERE can be no doubt that the relative positions of Great Britain and Germany as regards scientific preparedness show a complete reversal in our favour when a comparison is made between the present times and the autumn of 1914. In those days the official encouragement of scientific and industrial research in this country, and of the training and conservation of scientific workers was still in its infancy. The National Physical Laboratory, it is true, had been in existence and had been doing much excellent work for about a dozen years. The Advisory Committee for Aeronautical Research was in being two years or so before the outbreak of war. At Farnborough, the Royal Aircraft Factory had, substantially, ceased to be a factory in the ordinary sense and had been reorganised on a full-scale experimental basis. At the universities, and at the Imperial College of Science and Technology, substantial facilities existed for the conduct of research and for the training of scientific workers. Nevertheless the official attitude towards science as an aid to winning the war was unmistakably indicated by the complete freedom with which scientists and technically trained men were allowed to give up their work and join the infantry. Many of them could not later on be recovered from the Army and not a few were killed. The war was, in fact, well on its way—July, 1915—before the first steps were taken towards creating the official organisation now known as the Department of Scientific and Industrial Research, and it was not until December of the following year that the new Department began to play any important part in the national war effort. The war was more than half over before the Admiralty Research Department, as we now know it, was established in 1917. When we recall the deficiencies which the war soon revealed in our home resources of supply of optical glass and lenses, dyestuffs, high explosives, gauges of all kinds, fertilisers, sugar, and other essentials we get a further indication of the lack of scientific preparedness with which we entered upon it in 1914. By contrast, the Germans were very far ahead of us. For them the war began at the very peak of their country's deservedly high scientific reputation. They were easily the world's leaders in all branches of organic chemistry, and in many sections of inorganic chemistry. They had advanced a long way towards achieving practical success in the hydrogenation of coal and the fixation of atmospheric nitrogen. In the metallurgical—particularly the steel—industries they were leading the world in new developments. In many minor, but none the less vital directions such, for example, as the manufacture of magnetos, their scientific enterprise had resulted in placing them in the foremost position in the world's markets.

To-day the picture is very different. The impetus which the war of 1914 gave to the study in this country of science and its practical applications has not been allowed to wane. With each year it has, on the contrary, grown until to-day British industrial scientific research, official, and private, can well be claimed to be unsurpassed by any other country's except perhaps that of the United States. During the years between 1918 and 1939 we have had repeated reminders of the growing might of Britain's ability to direct science towards practical industrial ends. The winning outright of the Schneider Trophy demonstrated unmistakably that in aeronautical research, and in our ability to apply its results in practice we had no rivals to fear. In aero-engine design and manufacture we progressed from an almost complete dependence in 1914 upon foreign productions to a state in which British engines were being sought by nearly half the Air Forces of the world, and were being manufactured abroad under licence in many countries. The development of the all-metal aircraft dates from the last days of 1918. It is no idle boast to say that in that development British scientists and engineers have played a leading part, and have been the pioneers in several important directions, such as the evolution of the geodetic system of construction. In fields other than aeronautics anyone not blinded by the weakening influence of self-depreciation can read the same tale for himself. Illustrations are to be found in the developments made in this country during the past twenty years in motor-car engineering, wireless science, television, the plastics industry, naval architecture and ship propulsion, the electrification of railways, and in the continual evolution of the steam locomotive. It is not too much to say that at the present moment the scientific resources, in person and in kind, at the command of this country are such that there is scarcely any conceivable problem which is likely to arise in the course of this war which will not be speedily solved or reduced within tolerable bounds. What is the corresponding position in Germany to-day? Many of the best German scientists have, like Einstein, been driven out of their native country for purely political reasons, or have been forced by harsh persecution to abandon their professional work. Since Hitlerism came into power German science has suffered a decline. Apart from the madness of racial discrimination, it has been hurt by the interference of political propaganda with scientific education and it has been starved by the intense concentration on the immediate production of large stores of technical equipment. The German government's one aim has been to develop all possible means of producing munitions of war rapidly, and in large quantities, and to that end has recklessly sacrificed the essential flow of new scientific recruits and new scientific ideas to industry.

It would appear to be well established that the Germans, shortsighted although their policy towards science undoubtedly has been, have succeeded in creating a highly efficient machine for giving practical effect, on mass production lines, to scientific discoveries and developments. So far no evidence has reached us that the quality either of their materials or their workmanship has deteriorated by reason of the introduction of this intense drive towards an immediate high output or by reason of any difficulties they may have experienced or may now be experiencing in obtaining raw materials. For the momentary purpose of the present war their policy may be considered to have achieved its aim. The weakness—possibly the fatal weakness—of the position lies in the failure to provide in full measure the scientific resources necessary to adapt the production machine to unforseen war-time contingencies and surprises. After the war, the Nazis neglect of science will have a disastrous effect on the German nation. It is not unlikely to prove a decisive element in their defeat.

Training in Foremanship

Incidit in Scyllam qui vult vitare Charybdim may perhaps be loosely translated "out of the frying pan into the fire," and it graphically portrays the lot of the average foreman who lives daily in perpetual fear of disaster befalling him on either side. He endeavours to the best of his ability to steer his frail craft in such a way as to avoid the rock of offence to higher authority without at the same time being engulfed in a veritable whirlpool of disputes with the men working with him, or with the unions which safeguard the interests of the worker. Undoubtedly old Charon had an easier task when summoned to convey his living freight across the broad waters of the Styx, and was he not entitled to judicious bribes for his services? The intrepid sailor who would negotiate those narrow waters between Italy and Sicily would have stood but a poor chance of steering a clear course between the dreaded, jagged, rocks of Scylla, and the more insidious whirlpool of Charybdis, were he not well versed in the art of navigation. Both he and Charon undoubtedly held their pilot's certificate, awarded after an intensive course of training and practical experience.

But how does our engineering foreman secure his post? Were he himself to be asked the specific question he would probably reply more or less in the language of Topsy "'specks I growed." Were his employer confronted with a similar query he would probably say that it was because the man had proved to be a good mechanic, or

because he was a conscientious worker, certainly not on account of his having qualified after a definite period of education. The hackneyed contention that poets and artists are "born not made" is so oft repeated that we tend to believe it without reference to the time they have bestowed on the study of metre, the mixing of paints, and the general technique of their trade. Though it is not claimed that foremen are born and not made, the manner in which engineers appoint their foremen would appear to suggest that they fully subscribe to such a tenet. It may be argued that a prospective foreman has not the time to go to school, nor indeed has he the inclination, but there are other means of training, none the less effective, which it is well to consider. If he is to guide his men on lines that will be acceptable to the management he must at least have some personal knowledge of the aims of that management. Too often it is a case of hit or miss, with an appreciation of the adage *experientia docet* from a wrong angle, that of failure. Years ago the Royal Ordnance Factories at Woolwich when in the throes of reconstruction after the 1914–18 war set to work to initiate the foremen and other executives into the mysteries of their calling by holding, during the winter months, a series of so-called "efficiency meetings," at each of which some function of the organisation was freely discussed, a whole evening being devoted respectively to estimating, rate fixing, planning, storekeeping, or production—to name a few. Undoubtedly these meetings did much unostentatiously to train foremen and others, and the general outlook of the staff was widened. But we understand that they had certain drawbacks in that foremen felt that they were expected to attend in their "own time" while the upper management held their meetings in "firm's time." Again, men who were slow of speech suspected that they were losing caste before glib young men whose idea was rather one of self-advertisement than of contributing to the well-being of the whole organisation. That this was not actually the case can readily be imagined, but a number of such considerations tended to create an unnatural atmosphere. On the whole, however, there is no doubt that these efficiency meetings served a useful purpose. Frank discussion brings weak spots into the limelight, often quite unintentionally, and it would probably be of real value to arrange for occasional foremen's meetings to be held during normal working hours. It would give the foreman's understudy a chance to make good, and might be the first step towards training him while his chief was receiving wider education elsewhere. Perhaps the best education of all can be secured in a way that would probably be appreciated by most foremen, and yet is too often frowned on by the management; that is by the exchange of visits between progressive firms, which will often give the foreman an entirely new point of view. Johnson has truly said that "all travel has its advantages. If the passenger visits better countries, he may learn to improve his own; and if fortune carries him to worse, he may learn to enjoy his own." The same sentiment may very readily be adapted to a foreman's visits to other works. It may be contended that many works do not encourage visitors as they are unwilling to have their methods copied by potential competitors. On the other hand a really live firm will not withhold information and facilities, realising full well that if anyone slavishly copies them, by that time they themselves will have progressed still further!

In certain cases selected foremen have been asked to attend management meetings, and to express their views, views that have often been enlightening to the management, which, however, may have failed to realise how valuable such meetings have been in further educating the foreman. Incidentally they have also served another purpose in that they have afforded the foreman an opportunity of ventilating some of the feelings of the workshop before they have developed far enough to produce actual unrest. The foreman no longer feels that he is placed in that uncomfortable position between the upper and nether millstone, for he will recognise that he holds a position of trust, and that his services are now appreciated at their true value. Admittedly there is no royal road to success, but we seriously suggest that instead of adversely criticising their foremen, or expecting the impossible from them, managers should rather ask themselves what constructive steps they are taking to fit these men for the important posts they hold in the organisation.

The Paris Trade Fair

THE decision to hold the Paris Trade Fair from May 11th to the 27th coincides with a new phase of commercial and industrial relations between Great Britain and France that appears to have wide possibilities. Everything now depends upon a confidence and intimacy with which ideas underlying the agreement are carried through to a final conclusion, and those qualities are certainly not lacking. But there is a psychological aspect of the new trade conditions to be taken into account, and that is the effect upon French public opinion which, while receiving this fresh evidence of Anglo-French solidarity with great satisfaction, is nevertheless not quite sure how it will work out. British manufacturers have lost most of the ground they formerly held in France, mainly in consequence of the disparity in values that followed upon the French monetary inflation. Goods of British manufacture got the reputation of being too dear. Since the beginning of the war the two currencies have been stabilised in relation to each other, and the result has been to produce a feeling of settled confidence that must be maintained in the future. At the same time, German competition in France has entirely ceased, leaving the market open to British trade. While French buyers of machines and other engineering products know that they can obtain what they require from Great Britain, or could obtain them if it were not for the war pressure on industry and for the complicated import formalities that have now been relaxed and simplified in the case of imports from Great Britain, it is still desirable to familiarise the French with British goods, and in present circumstances an effort to do so would be taken as a compliment and a tangible sign of Franco-British solidarity. Notwithstanding the difficulty of preparing the Fair in war time, great efforts are being made, at the instigation of the Minister of Commerce, to uphold its traditions. The participation of some neutral countries will enable the Paris Fair to preserve its international character. Whether or not the presence of British manufacturers would bring to them immediate business is of less importance than the psychological effect it would have on the permanency of the industrial relations between the two countries.

The Institution of Naval Architects

THE annual general meeting of the Institution of Naval Architects, held in the lecture theatre of the Royal Society of Arts at John Street, Adelphi, London, W.C.2, on Wednesday, March 13th, was purely formal. No papers were presented at the meeting for oral discussion, but some papers are being circulated to members for written comments.

The President (Lord Stonehaven), who has consented to remain in office for the duration of the war, was in the chair during the early part of the meeting.

Referring to the proposal that he should be re-elected, he said there ought to be changes in the presidency, as there were in the council, to introduce new blood and to give others the chance to enjoy the many satisfactions belonging to the position which the members had been good enough to confer upon him. But that could not be done during the war and he was honoured by the request to remain in office.

It would be agreed that British naval architecture spoke for itself in no uncertain voice. It was contributing, not merely to the safety of the country, but to the admiration which the rest of the world felt for Great Britain. That was not an unqualified admiration generally, but so far as naval architecture was concerned one could say that it was unqualified. Thank God we had had such naval architects as we had had in the past and that we had such naval architects as we had to-day; more power to them, and long might they continue to maintain the splendid standard which had put us in the position in which we found ourselves in the most critical times of our national life.

Seeing Mr. McNeill at the meeting, the President congratulated him on the safe arrival of his second child—the "Queen Elizabeth"—in America. It was a magnificent performance, he said, and one could imagine Mr. McNeill's relief on learning of the safe arrival of the vessel. Nothing was more satisfactory than to note how sick the Bosch were over it; their dissatisfaction at the safe arrival of the vessel was one of the few light spots of the war.

(At this stage the President asked the meeting to excuse him as he desired to attend the memorial service to the late Lord Crawford and Balcarres. He wished the members the best of everything, including a victorious ending to the war).

Sir Eustace T. D'Eyncourt (honorary vice-president) occupied the chair for the remainder of the meeting.

The annual report of the Council for 1939 was adopted. It shows that the membership remained constant at 2576 and that the financial condition was satisfactory.

The Premium for 1939 has been awarded to Mr. A. Nicholls, R.C.N.C., for his paper "The All-Welded Hull Construction of H.M.S. "Seagull," and the Wakeham Prize to Mr. A. Emerson, B.Sc., for his paper "The Effect of Shape of Bow on Ship Resistance (Part II)."

The following elections were unanimously agreed to:—President: The Rt. Hon. Viscount Stonehaven. Vice-Presidents: Sir Westcott S. Abell, Lord Weir, Professor P. A. Hillhouse, Sir John E. Thornycroft, Sir Harold E. Yarrow, Bt., Professor T. B. Abell, G. S. Baker, Sir Maurice E. Denny, Sir Stanley V. Goodall, James Montgomerie, A. T. Wall, Sir Amos. L. Ayre, and J. T. Batey.

Result of Ballot for Members of Council:—Vice-Presidents: Professor C. J. Hawkes, Eng. Vice-Admiral Sir George Preece, F. E. Rebbeck. Members of Council: J. L. Adam, John Austin, G. W. Barr, R. W. L. Gawn, A. J. Hendin, Summers Hunter, J. M. McNeill, M.C., LL.D., Henry Main, J. M. Ormston, M.B.E., H. B. Robin Rowell, W. Y. Williams. Associate Members of Council: Sir Robert Hadfield, Sir George Higgins, Vice-Admiral Sir Cecil P. Talbot.

The meeting elected 86 new members to various classes of membership.

Obituary

WALTER C. MACARTNEY

BY the tragically sudden death of Walter C. Macartney on Saturday, March 9th, at the age of 63, the country has lost the services of an engineer with experience which is rare and which can be ill-spared at the present time.

Walter Crealock Macartney was the son of Colonel Arthur Sutherland Macartney, R.A., and was educated at the Dragon School, Oxford, and at the Oxford Military College, Sir Eric Geddes being a contemporary of his at the same school.

On leaving school in 1893 he became a pupil with Sir W. G. Armstrong Whitworth and Co., Ltd. at Elswick and was one of the numerous band of distinguished engineers who were there at that time when the works were under the chairmanship of Sir Andrew Noble, and the gunnery and gun mounting department under Captain Lloyd. In those early days practically the whole technical progress of naval gun and gun mounting design was developed at Elswick and the ships which were built under the Naval Defence Act of 1888 were almost entirely armed by Messrs. Armstrong's. Macartney remained on the staff after his apprenticeship and was sent out to various shipyards to oversee the installation of the heavy gun mounting machinery.

He was a keen volunteer officer and as a Subaltern in the Elswick Battery he fought in the Boer War and was promoted to the rank of Captain. On his return he rejoined the staff of Messrs. Armstrong's for some time but, in November, 1907, he was appointed as assistant to Sir William Ellis at the Atlas Works of John Brown and Co., Ltd., in Sheffield. Shortly before this date the two firms of Browns and Cammells had started the Coventry Ordnance Works and Macartney, with his knowledge of guns and gun mountings, was selected in 1909 as the first works manager and then as general manager. He remained at Coventry during the busy period before the Great War and

right through the struggle from 1914 to 1918, and was responsible for the large output of guns and mountings which were produced by the Coventry Ordnance Works during that period.

In 1918, Macartney joined as joint managing director the firm of Messrs. Walter Somers and Co., forgemasters, at Halesowen. He was approached by the Government to take over the supervision of Woolwich and the other Government factories but declined the appointment, as the restrictions imposed did not appeal to him and he preferred to remain in purely civil employ. In 1924 Macartney again returned to Sheffield as general manager of Sheffield Steel Products where he remained for a short time during the process of reorganisation through which that firm was passing. In 1927 he was appointed managing director to Messrs. Markham and Co., Ltd., the well-known engineers at Chesterfield, where he remained until his death. During his period of management the firm was connected with various important tunnelling works carried out in this country and abroad over the last few years, having constructed the shields used for the Mersey tunnel and for the numerous extensions for the London tube railways. He was also responsible for the construction of the very powerful winding engines required for the deep gold mines on the Rand, and developed the construction at Chesterfield, under licence, of various water turbines required for hydro-electric installations.

He was for many years a member of the Institution of Naval Architects and also of the Junior Institution of Engineers. He had been President of the Chesterfield Chamber of Commerce and took a great interest in technical education in that district.

Macartney was a well known and popular figure, and had a wide circle of acquaintances, who will mourn his loss, as he was much beloved by all who knew him. His particular interest was the formation and development of the Foremen's Mutual Benefit Society, with which he was connected almost from its inception, being a member of the executive council and having acted as vice-chairman. He was never happier than when improving the conditions and looking after the welfare of foremen and his popularity with them and the men in his employ was a remarkable tribute to his character.

H. KENNETH FRASER

WE greatly regret to announce the death on March 12th, of Mr. H. Kenneth Fraser, assistant manager of THE ENGINEER. Mr. Fraser was born in 1886. During the Great War he served in the London Scottish, in which he had been a volunteer for many years. After being invalided out of the service he went to the Ministry of Shipping till after the close of hostilities. On April 20th, 1923, he joined THE ENGINEER as assistant to the manager, which position he held until his death. He earned the respect and affection of his colleagues, and many business friends of THE ENGINEER will share our regret at his death. His outstanding characteristic was his unswerving loyalty to the paper which he served for 17 years.

Literature

The Physics of the Divining Rod. By J. CECIL MABY and T. BEDFORD FRANKLIN. London: G. Bell and Sons, Ltd. 1939. Price 21s.

IN considering the claims of water diviners, it is difficult for the well-instructed observer, used to the more definite knowledge available in subjects more fully developed scientifically, to withhold a suspicion that dowsing is merely another "mystery," akin, perhaps, to the traditional knowledge handed down generation by generation among the witch-doctors of African tribes, a thing of little more substance than an ability to deceive the gullible. Nothing is done to relieve such suspicions when extraordinary, almost magical, claims are made for the abilities of dowsers, such, for instance, as the determination of the fecundity of hens, the discovery at a distance of the whereabouts of criminals, or the divination of water supplies by the swing of a pendulum suspended over a map of the district concerned. Nor are scientists likely to be the more convinced of the efficacy of the rod when it is reported that if coloured ribbons are attached to it divination can be restricted to particular materials, blue ribbons for copper, black for gold, pink for lead, and so on. Such ridiculous claims inflict damage on the reputation of dowsers as a class even when they are put forward honestly and with no intention to deceive. The suspicion of dishonesty is, however, present. For it is clearly advantageous to an individual dowser, just as it is to the spiritualist medium, to pretend to greater knowledge or to more abstruse powers than he does in actual fact possess. That kind of distrust in the ability of dowsers can never be removed until their powers are more exactly defined by the development of a satisfactory scientific theory covering the mechanism of their actions. Nor is any explanation likely to reduce scepticism until the results obtained can be recorded instrumentally without the intervention of a fallible pair of human hands holding a divining rod.

To judge by the number of books written about dowsing, the majority of which have attempted explanations of the phenomena, the truth regarding the status of the art, in the eyes of scientists, has been very well understood by diviners for many years. In more modern works the attempt to explain the action scientifically has usually been made by calling into play electrical or magnetic qualities, or by supposing that streams, wells, buried metals, &c., themselves generate electro-magnetic waves or that their presence influences the lines of flow of such waves from external or cosmic sources. Amongst other well-known dowsers, Henri Mager attempted an explanation on these lines without, however, carrying conviction to the sceptical scientific mind.

The book now under review constitutes a more ambitious attempt to account scientifically for dowsing reactions. Its authors are respectively a physiologist and a mathematical physicist and their bona fides are unquestioned. The work was written under the auspices of the British Society of Dowsers. In its first part the experiments of others are reviewed, and mention is made of a number of facts and phenomena which appear to have a bearing on dowsing. It is here emphasised that the work of the authors is restricted only to physical as opposed to physiological effects and that no attempt is made to explain the work of dowsers who claim to operate on some plane other than the physical. That restriction will commend itself to scientists. For the work of dowsers claiming to operate by physiological or other means seems perilously akin to that of the spiritualist medium, about whom there persists in hanging an aura of unrespectability. In the remainder of the book the authors describe at considerable length the very large number of experiments they carried out personally. This part is of interest, and merits close study; for it is claimed that any competent observer could repeat the experiments and attain the same results. Upon these experiments the authors have considered it possible to found a coherent mathematical theory. The explanation is offered that, as a result of purely physical causes, the dowser's muscles are influenced by the proximity of water, metals, &c., with the result that entirely involuntary movements occur, causing the divining rod, which acts as an indicator, to move in the well-known manner.

No comment is offered on the authors' theory. It remains for dowsers and scientists to check the results and to decide whether the theory is tenable and satisfactory. But, even if the decision be adverse, it is clear that if and when a complete scientific theory of the actions of dowsing is established, the work carried out by the authors of this book will be considered one of the more important stepping stones towards its achievement.

BOOKS RECEIVED

Aircraft Identification. London: Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 1s. 3d. net.

Mining Year Book, 1940. Compiled by W. E. Skinner. London: Walter E. Skinner, 15, Dowgate Hill, E.C.4. Price 10s. net.

Industrial Law. Second edition. By H. Samuels, M.A. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, W.C.2. Price 15s. net.

European Science. By H. Stafford Hatfield, Ph.D. Cambridge: The Basic English Publishing Company, Ltd., 10, Kings Parade. Price 3s. 6d. net.

Electrical Engineering Science. By A. Morley, O.B.E., D.Sc., and E. Hughes, Ph.D. London: Longmans, Green and Co., Ltd., 39, Paternoster Row, E.C.4. Price 5s. net.

The Calculation and Design of Electrical Apparatus. Second Edition. By W. Wilson, D.Sc. London: Chapman & Hall, Ltd., 11, Henrietta Street, W.C.2. Price 10s. 6d. net.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

SPECIAL EQUIPMENT AND SMALL FIRMS

SIR,—It is known that a considerable number of small engineering firms are unable either to pursue their normal peace work to capacity or to launch out on war work—in the main because the limitations of their works and labour force preclude award of the large orders which would favour economic production.

It is believed that a number of larger firms are anxious either to expand or else to speed up production on government contracts. Some of these firms are known to be seeking specialised equipment which—because of delivery delays at home—can at present only be obtained more rapidly from Italy or America. Such purchase of equipment would make inroads on the currency, which it is desired to preserve as much as possible.

It would, in these circumstances, seem to be of much advantage if the Ministry of Supply were to organise a bureau for the disposal of the specialised plant now immobilised in the small factories. Small engineering firms might be invited to offer their idle equipment for hire for the duration, or for immediate sale, through this bureau. This would in nowise amount to conscription of production equipment since only those small firms which desired disposal of their equipment would send their offers to the bureau.

Such a clearing system would marshal reserves, now unproductive, in the national effort. The proposed bureau need be only of very limited staff, acting in liaison with government overseas trade offices. Thus, as soon as a British firm applied to Control headquarters to purchase certain special equipment abroad, the Control would contact the bureau and promptly advise the applicant of any equivalent plant available for hire or purchase in Britain. The bureau might also serve as a clearing station through which firms now faced with long delivery dates on equipment urgently needed might find satisfaction promptly. ONLOOKER.

Traffic on Paved and Unpaved Roads

A LARGE proportion of the highways system of the United States consists of secondary roads, having some form of gravel surfacing or consisting of the natural soil dressed to shape. Such conditions prevail probably in many foreign countries and colonies. On roads of this character two operating difficulties are snow and mud. In districts having soft prairie soil vehicles are sometimes equipped with drums outside the wheels to prevent the car or truck from being mired in "bottomless" mud. For snow, they may be equipped with skids and endless-belt crawlers. To determine the relative cost of operating on paved and unpaved roads a study has been made of the rural mail service. Two general conclusions are as follows: first, a considerable increase in expenditures on secondary roads is justified to eliminate muddy roads and dusty gravel, the operating costs on which are from 1d. to 4d. per vehicle-mile higher than on cheaply paved roads. Secondly, in the northern States, highway departments are justified in an annual expenditure for snow and ice removal at the rate of £100 a mile of road per 1000 vehicles per day; this is based on saving in cost and time of vehicle operation and the reduction of accidents. The study indicated that the rural mail motor vehicles averaged 20,000 miles annually, on paved and treated gravel roads, as against 4000 miles on earth roads, while the speeds averaged 13 and 9 m.p.h. respectively. In summer the speeds were 14½ and 10½ miles, while in winter the averages fell to 11½ and 7½ miles respectively. The mail cars averaged 3000 lb. in weight, empty, and the weight of mail averaged 135 lb. It is estimated that the expense of a gravel surface on an earth road is justifiable when the traffic reaches 25 vehicles daily. Furthermore, an "all-weather" road brings advantages in fire protection, marketing, health production, schooling, and social opportunities.

PARACHUTE FLARES.—The dropping of flares over Berlin during recent R.A.F. reconnaissance flights has been reported. These parachute flares are mounted in the bomb-rack of the aircraft and are released in much the same manner as a bomb. The nose of the tubular case containing the flare, with small parachute attached, is fitted with a vane which causes a small explosion when the case has fallen a certain distance. The explosion ignites the flare and blows it with the parachute out of the case. The parachute opens and supports the flare, the heated air rising from the burning magnesium giving extra buoyancy. The flare falls very slowly and often remains poised for some time. Parachute flares are mostly about 8in long and burn for nearly ten minutes. They shed a brilliant light—as much as 2,000,000 candle power or more, according to size.

Road over River Mersey at Stockport

By ERNEST RHODES

AT Stockport work is in progress for the covering of 411 yards of the River Mersey, and the constructing of a reinforced concrete road. A number of engravings illustrate the work. About 1906 a preliminary scheme was prepared for a vaulted brick arch covering the river from Mersey Bridge to Lancashire Bridge. In 1925 the plan was revived again, but an adverse report from consulting engineers resulted in the Borough Surveyor (Wm. F. Gardner, M.Inst.C.E.) preparing a scheme which would not necessitate obstructions in the river. Delay was occasioned through the financial crisis of 1931, but in July, 1936, work started.

PORTALS UNDER CONSTRUCTION

Messrs. J. L. Kier and Co., Ltd., London, tendered at a figure of £108,000 (which excludes asphalt road surfacing, tram track alterations at Lancashire Bridge, fees, &c.). The estimated all-in cost is £140,000.

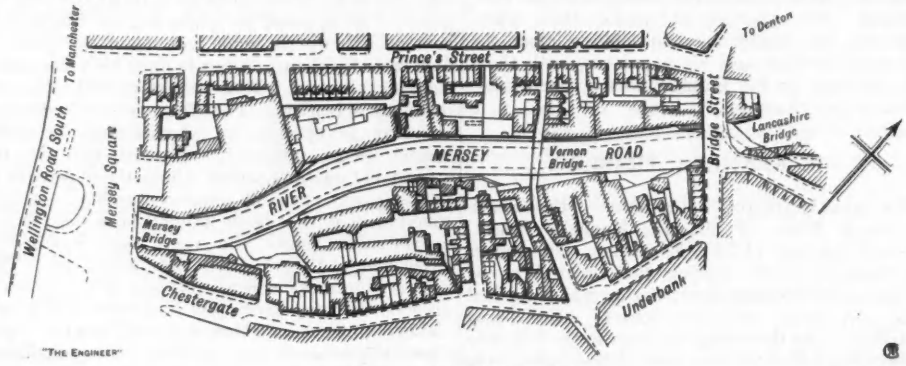
The total length is 411 yards, with a width of 75ft. (see plan), increasing at both ends to form a bell-mouth entrance. The plan also includes a triangular widening on the eastern side of Lancashire Bridge of approximately 29 yards by 23 yards. When completed, some 2000 tons of steel will have been used, and 13,400 cubic yards of concrete.

A movable derrick with a 130ft jib on a track parallel with the river was first constructed, and meanwhile work on the foundations started. There are 111 of these, and in all cases they are in the red sandstone rock (the bands are 25ft. above the bed at the middle of the water course). The size of the foundations at the base is 12ft. by 8ft. 6in., designed to give a maximum pressure of 5 tons per square foot. Steel reinforcement in the form of a grill is fixed at the bottom and consists of 1¼in. and ¾in. round steel bars at 6in. centres, 1½in. from the bottom. Also in the foundations are raking leg splice bars and training wall splice bars.

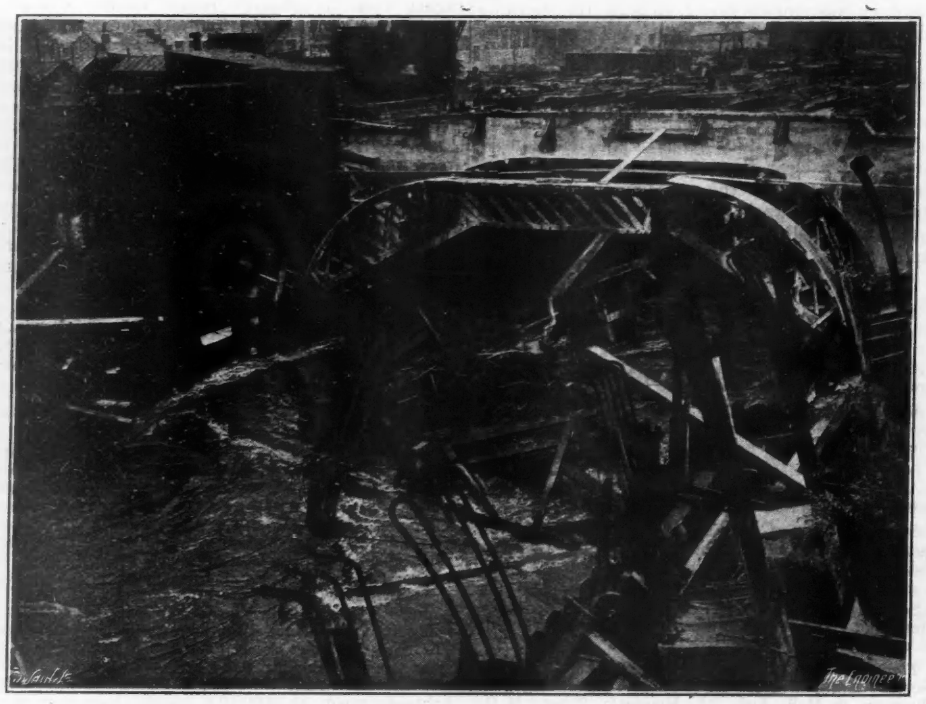
A timber gantry was built, consisting of timber frames which were assembled on the bank, and then positioned in the river. Steel girders span from frame to frame and carry a 12ft. gauge track on which runs a 5-ton steam crane with a 45ft. jib.

GENERAL VIEW OF WORK IN PROGRESS

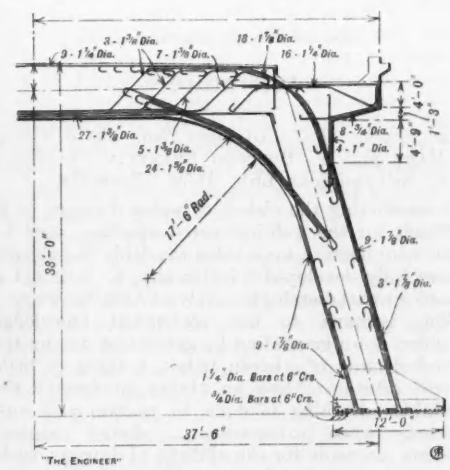
A No. 6 Kiernan Terry steam hammer has been used to drive the steel piles, and the average penetration into the rock has been 18in., but one pile, when extracted, was found to have penetrated 4ft. 9in. into the sandstone. Two 6in. centrifugal pumps with diesel engines and three 4in. diaphragm pumps have kept the dams dry. The 12ft. gauge crane on the gantry has done all the driving and drawing of the steel sheet piles of the coffer dams, and the moving up of the gantry as work proceeded. Steel sheet piling has been used on all cofferdams, and has proved very successful, although the dams have blown occasionally through the piles not being driven deeply enough into the rock. This happened with the steel pile cofferdam on the north side of the river; it was necessary to drive a new dam.



PLAN OF RIVER MERSEY ROAD



DAMAGE BY FLOODS



REINFORCEMENT OF PORTAL

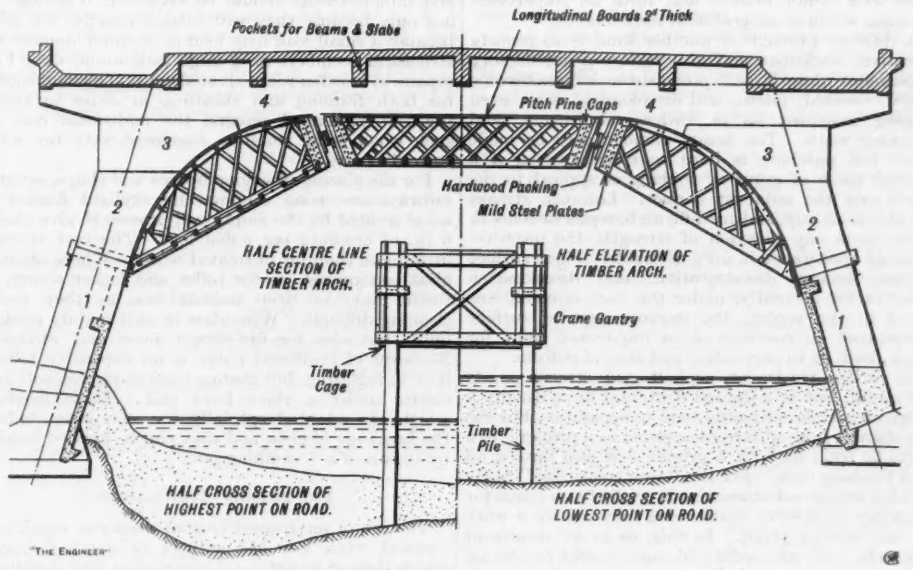
Haunches and portal beams are supported by collars made of steel joists and fitting round the top of the portal legs. The collar is bolted into the concrete at the back of the leg, and timber is used as a support from the top of the training wall. The timber centre sits on a steel girder, suspended from the two side members of the collar by eight bolts, which are used for adjustment, and are slacked off to strike the centre.

Some difficulty has been experienced from flood water. On January 6th, 1937, after heavy rain, the river rose 10ft. in one night alone, and washed away a complete section of the gantry. An old timber weir across the river caused some trouble, too. It was completely buried, and its existence unsuspected. Piles could not be driven through it, and therefore the dam was pumped out, and the baulks which formed the weir were cut off, to enable the piles to be driven down. It is always an anxious time, of course, when the Mersey is in spate, but for some time now no trouble has been encountered, and work has progressed smoothly.

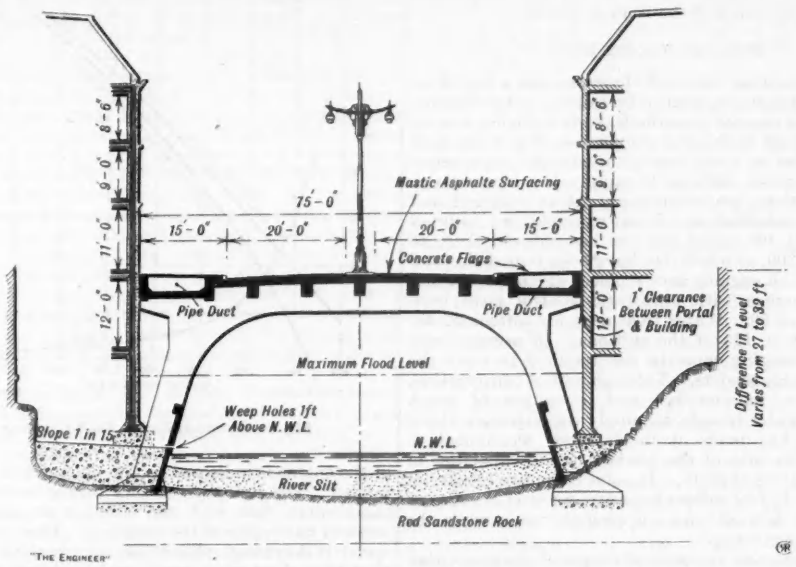
The structural details are as follows: The roadway between Mersey bridge and Lancashire bridge is to be carried on fifty-four portal frames, with an expansion joint between each group of six portals. The spacing of portals is 25ft. centres with 15ft. centres at the expansion joints. This spacing is maintained on the outside of the curved lengths. The foundation block 12ft. by 8ft. 6in. is designed to give a maximum pressure of 5 tons per square foot on the red sandstone rock, on which the whole structure is built. The portals are 4ft. wide, with sloping legs 5ft. by 4ft., and a main beam 5ft. 9in. by 4ft.; secondary beams 16in. by 2ft. 4in. at 9ft. centres carry the 9in. slab to the carriageway. The cantilever brackets on the back of the portal legs carry the slab and secondary beams forming the duct provided under the footpaths. The services laid on the ducts will be buried in sand and the flags laid on the sand filling. A ¾in. asphalt lining will be applied to the concrete surface on the duct, and drainage outlets provided at each expansion joint.

Blocks of wood 4in. by 4in. at 10ft. centres are built into the top of the side walls to the duct so that if necessary they can be cut out and connections made to the service mains. The expansion joint is covered with 4in. copper plate bolted to one side.

Training walls 8in. thick are built between portal legs to a height of 8ft. above normal water-level (maximum rise ever recorded, 14ft.). The space between back of training walls and existing river walls, or rock sides to the river, are filled with mass concrete (after excavation of all river deposit) and brought up to 1ft. above normal water-level. This mass concrete forms the foundation for further developments alongside the road.


Pockets for Beams & Slabs
Longitudinal Boards 2" Thick
Pitch Pine Caps
Hardwood Packing
Mild Steel Plates
HALF CENTRE LINE SECTION OF TIMBER ARCH.
HALF ELEVATION OF TIMBER ARCH.
Crane Gantry
Timber Cage
Timber Pile
HALF CROSS SECTION OF HIGHEST POINT ON ROAD.
HALF CROSS SECTION OF LOWEST POINT ON ROAD.
"THE ENGINEER"

ARRANGEMENT OF CENTERING FOR PORTALS



TYPICAL CROSS SECTION OF ROADWAY

UNDERSIDE OF ROAD AT MERSEY SQUARE

The surface works will comprise a 45ft. carriageway with eight central islands (20ft. by 5ft.) and two 15ft. footpaths. The road surface will be formed of 2in. rock asphalt with kerbs 12ft. by 8in. granite, and flags 3in. natural sawn gritstone. The islands are to have white rubber covered kerbs and concrete flags, and will carry two bollards and central lighting standards. Side lighting standards on the footpaths are to be fixed intermediately with islands, and the standards will be fixed in 12in. cast iron pipe sockets cast in the reinforced concrete decking. Special gulleys are to fit in rebates in the deck slab, so as to discharge through 90 deg. bends to the river. Wrought iron railings will be fixed along the back of the footpath to form a temporary parapet until development at the side of the roadway has occurred.

It is expected that work will finish about the middle of next year.

American Railway Bridge and Building Convention

MAINTENANCE and repair of railway structures, more than their design and construction, constitute the principal field for the officials composing the American Railway Bridge and Building Association. Much of their work, too—particularly on bridge structures—must be carried on under traffic or with the least possible interference to trains. In consequence, the proceedings of the annual meetings of this association have a rather special character, distinctive from that of the meetings of various other engineering societies.

DETERIORATION OF CONCRETE

At the 1939 convention, a lengthy report on "Deteriorated Concrete; its Causes and Remedies" listed a score of causes of deterioration, with occluded water as the most disruptive cause where low temperatures prevail. But practically all causes may be classed under "poor materials" or "poor workmanship." One of the difficulties in repair work is that after a structure has been completed there is little, if any, useful record as to material, workmanship or local conditions which prevailed during the original construction. Every repair job must be studied as an individual problem, and the remedy adopted will be largely a matter of judgment.

It is essential to distinguish between damage due to weathering of exposed surfaces and that resulting from water working through the concrete from its rear or buried side. Thus the subject has really two divisions. Firstly, the exclusion of water to prevent internal disintegration, and, secondly, the treatment of damaged exposed surfaces. To exclude water from the rear and buried surfaces of such common structures as retaining walls and bridge abutments, much use has been made of various bituminous coatings, applied alone or in combination with layers of felt or similar material to form a waterproof membrane on the concrete. This waterproofing may lose its efficacy in time, but as it is

concealed in the embankment the trouble may not become evident until after mischief has been done, while restoration of the waterproofing would be difficult and expensive. Another method of treating such buried surfaces is the application of cement grout under pressure, in order to seal all surface voids and minor defects and form an impervious covering which is integral with the concrete.

A difficult problem of another kind is to remedy defective conditions and also restore a satisfactory appearance where large exposed surfaces have become scaled, cracked, pitted, and discoloured, or are even seeping moisture, as in girders, abutments, and retaining walls. The actual damage may be made good, but patching is hard to conceal, even if a general finish of grout or rubbing is applied to the patch and the adjacent surface. Laitance streaks are also unsightly, and are difficult to repair or conceal. Apart from any question of strength, the improvement of appearance is very desirable. Since surface cracks, scaling, disintegration, and discoloration occur rather generally, under the various conditions noted in the report, the improvement of surface appearance on concrete is an important point for study, both as to prevention and cure of defects.

In surface treatment, asphalt and cement paints are useful, but in a limited field, and have usually a short life, while oil paints tend to saponify. For the last-named, tung oil is recommended as a primer; or a phenolic resin base for a primer coat and linseed oil as a finishing coat. For the "iron treatment" finely divided iron in sal-ammoniac is applied as a grout for patching, successive coats being followed by a wash of sand-cement grout. In this, as in all treatment methods, both successful and unsuccessful results are on record, owing probably to extreme differences in local conditions and workmanship.

The waterproofing of construction joints and structural cracks is difficult, especially where water under pressure is a factor. If the concrete is not subjected to freezing temperatures, narrow joints may be caulked. For surface patching, it is essential to leave proper preparation of the old concrete, usually by thorough cleaning and then the successive application of coats of thick grout. The shrinkage tendency of the new concrete may be avoided in many cases by mixing the new grout or concrete some time before it is to be applied, the length of this period being determined experimentally. If the new concrete is placed in forms, it should be in layers, each well rammed, and it is preferable to use vibrators.

Repainting

Bridge painting deferred long beyond the proper time on account of a financial situation is a trouble that involves excessive ultimate expense. This trouble is accentuated where refrigerator-car traffic is heavy, owing to the dripping of brine from these cars. A major item in deferred maintenance is the breaking and scaling of the old paint film, so as to expose the bare steel. The normal life of good paint depends upon local conditions, ranging from 12 or more years in warm, dry desert country, to 2 or 4 years near the sea coast. Cleaning the steel in preparation for painting represents normally about 25 per cent. of the labour cost, but with deferred maintenance this proportion may be increased to 50 or 75 per cent. And when the surface becomes roughened by deterioration, the future paints are not likely to last as long as the original coats.

Many railways have resorted to touching up bad spots with cement paint, asphaltic paints, asphalt emulsions, rust preventatives and rust inhibitors. Standard bridge paints made with mineral pigments and boiled linseed oil will give about four years' protection to the steel, but are not sufficient to withstand the blast from engine funnels or brine dropping from refrigerator cars. The use of rust inhibitors followed by priming and finishing coats of paint is still experimental. Where blast or brine are factors, more effective results may be obtained from coatings of oil or greasy matter with rust inhibiting substances.

When repairs, painting, or track work is being done on bridges it has been usual to issue orders to trains to reduce speed, but with the general tendency to increased speeds and shortened time schedules such interference must be kept at the lowest limit consistent with safety. This necessitates conference and close co-operation between the bridge maintenance engineers and the operating officers. Thus, a train halted when running at 90 miles an hour may have to run 20 miles before regaining its full speed, and at 75 miles an hour a train may lose 4 or 5 minutes before regaining speed. In maintaining the safety of structures, frequent inspection of both superstructure and substructure are necessary and where financial limitations delay regular repair work, many ways are devised for economical protection and repairs.

Roofs and Glazing

Roofs and glazing of engine-houses or running sheds and repair shops were the subjects of two reports, the information in which would apply to various other industrial buildings. With wood roofing, steam, smoke and gases may cause decay from the inside, sometimes to the extent of leaving the outside sheathing of bituminous felt, &c. almost without support. Poured or precast concrete or gypsum cause few maintenance problems, and require little more than periodical mopping of the exterior with a proper coating. Cotton fabric is being used to some extent instead of the more usual felt; both are applied with hot pitch or asphalt. Small leaks and minor defects should be attended to promptly, not only because they will enlarge rapidly, but also because a small leak may lead to as much damage to structural members as a large leak would do. For repairs to wooden roofs, treated wood is recommended for both framing and sheating, in order to avoid frequent piecemeal repairs, the additional cost of such wood being small as compared with the total cost of repairs.

For the glazing of engine-houses and shops, several railways are using window and skylight frames of wood treated by the empty-cell process to give about 6 lb. of creosote per cubic foot. The cost is very little more than for untreated wood. Where obscure glass is required, as for toilet and locker rooms, it should have no deep indentations, as they make cleaning difficult. Wire glass is used mainly in skylights but also for fire-escape doors and windows. Removal of hardened putty is an expensive labour item in reglazing, but glazing mastics remain soft and elastic under a thick hard skin. These mastics, which are adapted specially for steel sash, reduce the breakage of glass and they can be applied readily by means of a "caulking gun."

Pre-framed Timberwork

The use of pre-framed treated timber in repair and renewal work was the subject of another report, which showed its extensive application for a multitude of purposes in bridges and buildings. It is found entirely practicable to frame and bore the members before treatment and then assemble them in the field without trouble, but careful measurements in the first place are essential. Furthermore, the framing is more rapid and less expensive than framing in the field. Increased use of this practice may result from simplification of the framing plans.

Railway Water Supply

Of a somewhat different character was a report on modern pumping equipment for railway water stations. Changes in operating methods, such as higher speeds, larger tender tanks and longer non-stop runs have necessitated on many roads an extensive re-arrangement of water stations to supply the locomotives. Some stations are abandoned, others enlarged and new ones established. As an example, one railroad which had 400 water stations has reduced them to less than 300, of which 140 have been remodelled and enlarged; oil engines have replaced steam at 60; and electric pumps with automatic control have been installed at 50. Water treatment for softening, &c. is applied at 125 of the stations. In several cases greater pumping capacity was required to serve the modern large tenders. The high cost of construction, equipment, maintenance and operation of track tanks or water troughs to supply the engines without stopping has made it much more economical to increase the size of the tenders, up to capacities of 20,000 gallons or more. In some cases two tenders of 10,000 or 12,000 gallons capacity are used in order to avoid the necessity for stopping the train while the engine takes water.

Extensive use is made of deep-well pumps, either electrically driven or operated by oil engines, with material reduction in operating and repair costs. Thus in certain cases where the annual costs for steam plants have been £500 to £1600, that of newer electric pumping plants with automatic control have been £175 to £400 respectively. As to the advisability of purchasing water from city waterworks, where available, each case must be considered as to its merits and the local conditions, including the character of the water.

Subjects to be reported upon at the next annual meeting include modern water service conditions, experience with termite infestation in buildings, repair of ballasted-deck bridges, mechanical equipment for bridge and building forces, storage and delivery of repair material, heating of shops and terminal buildings, and protection of steel structures from corrosion.

Contact Corrosion of Aluminium.—An Air Ministry abstract from a German journal gives particulars of the effects of contact corrosion of pure aluminium with various metals. It is pointed out that experiments carried out with sheet metal samples to determine the contact corrosion of pure aluminium in conjunction with stainless steel, copper, and iron, show that steel of low nickel content or free from nickel behaves in practically the same way as the high nickel-content 18/8 Cr-Ni steel; the contact effect is many times smaller by comparison with copper or iron. Measurements of potential made after various corrosion periods showed that the aluminium-stainless steel elements can be very strongly polarised, but in absence of current high potential differences can occur. Insulation of the metals is therefore always to be recommended, particularly when subjected to the continuous action of liquid. Contact corrosion and polarisation depend strongly on the prevailing conditions. Corrosion phenomena due to the effects of cracks are considerably increased by contact currents.

Motor Transport*

By E. C. OTTAWAY, A.M.I.Mech.E.†

(*Continued from page 254, March 15th*)

Transmission.—At the present moment all goods vehicles and the great majority of passenger vehicles are fitted with four-speed sliding tooth or constant-mesh gearboxes and plate clutches. The only real improvement of a fundamental nature which has been made of recent years is the more general adoption of constant-mesh gears. This has resulted in improved tooth wear because of the elimination of the destruction of the leading edges of the gear teeth when changing gear. A considerable reduction in pitch line wear has also been achieved, presumably by the elimination of the damage caused by the entry of the detritus from the leading edges between the tooth flanks.

A demand for an improved form of transmission for urban omnibus working has enabled two specialised transmissions to be placed on the British market in reasonable quantities; these are the fluid transmission, marketed for heavy vehicles by the Associated Equipment and Daimler companies, and the Leyland Lysholm-Smith torque converter.

The fluid transmission combines the Föttinger or Vulcan hydraulic coupling with an epicyclic gearbox. Both are lacking in certain essentials, but together they form a complete system, whereas the fluid coupling with its persistent drag torque is not a happy mate for the sliding tooth gearbox.

The characteristics of the fluid coupling are illustrated in Fig. 8, which refers to a coupling of 405 mm. effective diameter coupled to an oil engine of 7·5 litres (462 cubic inches) capacity. The torque curve

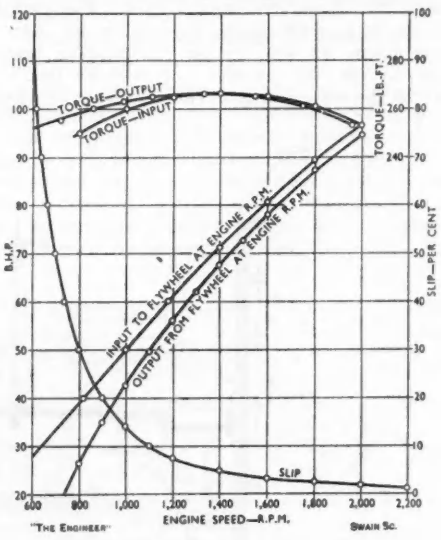


Fig. 8—*Characteristics of Fluid Coupling*

of the engine is indicated by the line marked "torque input." The line representing torque output is the same curve, but with the speed scale adjusted in relation to the slip of the coupling. Thus the output speed is decreased, which has the practical effect of flattening the torque curve, provided that the point of maximum torque is above the full-torque stalling speed of the coupling. The following important conclusions emerge:—

(1) The maximum torque of the engine is available at a lower vehicle speed than in the case of a friction clutch.
(2) It is impossible to provide an artificially high starting torque by racing the engine and absorbing the kinetic energy in a jerk start. This necessitates a sufficiently large engine or low overall gear ratio to meet all conditions.
(3) It is desirable that the gear ratio used for starting should be as low as possible in order that the coupling speed may be relatively high as soon as the vehicle is in motion, thus minimising the power dissipation. A ratio of 28/1 has been found a satisfactory compromise.

The epicyclic gearbox used in conjunction with the fluid coupling was developed by W. G. Wilson and is known as the Wilson preselective gearbox.

The London Passenger Transport Board operates some 2833 vehicles fitted with this form of transmission, representing an annual mileage of 142,000,000. It is therefore clear that it is well beyond the trial stage. Before standardising the transmission, a great deal of experimental work was carried out under service conditions, and several important points in relation to its operation have arisen. The early experiments were carried out on vehicles fitted with petrol engines and considerable difficulty was experienced in obtaining satisfactory idling of the engine against the resistance of the drag torque of the fluid coupling. This factor is of great importance, for the following reason. The essential condition for eco-

* Excerpts from a paper to have been presented at the 1939 American Meeting of the Institution of Mechanical Engineers.

† Technical Officer (Buses and Coaches), London Passenger Transport Board.

nomical operation of the fluid transmission on urban services with frequent stops is that the starting of the vehicle from rest should always be carried out through the fluid coupling and not through the gearbox bands, otherwise excessive temperatures will be set up in the gearbox, resulting in oxidisation of the lubricant and eventual destruction of the gearbox. To enable this to be done, the required gear must be engaged before accelerating the engine. Unless the idling of the engine is good, there will be a tendency for it to stall when the load of the drag torque is suddenly applied. To overcome this difficulty, it is necessary to increase the flywheel weight and to make a careful study of carburation.

When used with the oil engine, this difficulty is entirely overcome since the low-speed governor increases the slow-running injection immediately the engine speed commences to stall as a result of the application of the drag torque load. It should be made clear that provided there is little tendency for the engine to stop, the driver will naturally prefer to preselect the required gear and to start the vehicle entirely on the fluid coupling.

The use of this transmission with oil engines has the further considerable advantage that it entirely eliminates the transmission of the torsional oscillation of the engine crankshaft to the gearbox, cardan shafts, and rear axle. Vehicles equipped with fluid couplings have been found to be free from transmission breakages and noise. The author is of opinion that for the satisfactory operation of oil-engine omnibuses under congested city conditions some form of hydraulic coupling is essential.

By the very nature of the hydraulic coupling it can never operate at 100 per cent. efficiency; an increase of fuel consumption is therefore occasioned by its use. Experience has indicated that this need not exceed 3 per cent. as compared with the orthodox type of clutch and gearbox under city conditions. The extent to which the ordinary clutch is slipped by the average driver is often not realised.

The improved quietness with the epicyclic gearbox has been more than sufficient to counterbalance the increase in engine noise occasioned by the use of oil engines. Observation in a crowded thoroughfare will confirm this, particularly if the observation be made near a bus starting point. The noise of partly worn sliding-tooth gearboxes drowns the remainder of the sounds made by the mechanical parts of a bus.

Experience with fluid transmission from the maintenance point of view is satisfactory. The repair cost of the flywheel is extremely low, since the wearing parts consist only of two ball races and the gland. The gearbox is more expensive to repair, but compares favourably with the ordinary type on a mileage basis. The rate of tooth wear is extremely low as a result of the very light tooth pressures. In combination, the maintenance cost of the epicyclic gearbox and fluid coupling is lower than that of the ordinary clutch and gearbox, particularly if the maintenance of a high standard of silence be attempted with the latter.

The Lysholm-Smith torque converter, manufactured in England by the Leyland Company, is also based on the Föttinger system incorporating a coaxial pump impeller and turbine through which a fluid is circulated. The essential difference lies in the fact that with the Lysholm-Smith design it has been possible by means of the improved multiple-stage turbine blading to obtain a relatively flat efficiency curve at about 85 per cent. For use in road vehicles, it has been deemed advisable to provide an alternative direct drive for all cases where a 1/1 ratio is normally employed, thus obviating the necessity of obtaining higher speed at a falling efficiency. The direct drive is introduced by means of a two-way clutch which disconnects the pump element from the engine and connects the flywheel directly to the output flange of the converter. The turbine, which drives the output shaft by means of a free wheel, automatically disconnects itself from the drive and the whole hydraulic system comes to rest.

A large number of these transmission units are in use in Great Britain and it is clear that this transmission has also passed the trial stage. The outstanding advantage is the smooth start and acceleration up to approximately 20 m.p.h., and the single control movement required to engage direct drive.

An assessment of the relative merits of the alternative transmission systems is difficult because they are largely dependent upon operating conditions and individual opinion. The relative merits according to the author's opinion and experience are given under a series of selected headings in Table IV. Where figures are given, they are based on conditions prevailing in London, and may vary in other places.

Careful observation has shown that an improvement of about 10 per cent. is obtained in tyre life when some form of fluid drive is used, and this advantage must be borne in mind when making comparisons with the friction clutch.

The problem of making the transmission fully automatic has received considerable attention of late, in conjunction with improved methods of gear shift by servo or power means. The first steps taken by the author in this direction were the direct result of the removal of the engine and gearbox to a position remote from the driver, and the necessity of providing finger-light controls to counteract the increasing fatigue produced by modern city traffic conditions. The first attempt comprised air operation for the Wilson gearbox in combination with electrical selection of the gears. The main spring of the gearbox was replaced with an air cylinder and the gear selection camshaft by electrical solenoids; the arrangement worked well and is still in use.

Later, a double-deck bus was equipped with an ingenious automatic transmission developed by A. A. Miller. This transmission uses the ordinary fluid coupling and epicyclic gearbox of the type referred to above, having an air cylinder in place of the main spring together with electric gear selection solenoids. The control of the transmission is obtained by a combination of throttle position (representing load) and engine speed.

The equipment was fitted to an oil-engine bus operating in Central London and completed a mileage of approximately 1800. The arrangement worked almost perfectly in relation to load and speed and could, moreover, be influenced by the driver to some extent by careful throttle movement. For instance, if running steadily in third gear at half load, a momentary closing of the throttle would precipitate an upward change. The experiment was particularly valuable in that it afforded an impression of the value of full automaticity. It became clear, however, that drivers were not inclined to favour fully automatic control, although its performance was better than all but the most skilful handling. Drivers prefer to retain some measure of control over the torque ratio, and in consequence the apparatus has now been altered so that upon the movement of a lever the gear changes are automatically made and correctly timed. It was also noticeable that there was a slight increase in fuel consumption when operating with the fully automatic gear, probably because the gear changes were arranged to take full advantage of the engine output, whereas, in fact, the driver does not always do so. This factor is also against full automaticity. After experiments extending over a period of twelve months and a total distance of some 30,000 service miles, the author inclines to the opinion that fully automatic gears are not required, but that the necessary gear changes should be capable of being made with the minimum of effort and should be timed automatically to prevent jerk or undue stress on the transmission.

Braking.—The primary consideration in braking is the effort that is capable of being exerted by the driver. Experiments conducted by Sisman (1936–37) indicate that a comfortable pressure for a man to exert is of the order of 80 lb., although pressures as high as 455 lb. could be exerted momentarily by a heavy man. These figures are of interest, since they show that, due to the toggle action of the human leg, it is possible for an individual in an ordinary driving seat to exert a force approximately twice his own weight for the short period necessary to accomplish an emergency stop. In a commercial vehicle, however, where the driving position is more upright, the possible effort must be reduced by about 25 per cent.

A road vehicle being braked with a deceleration of 25ft. per sec. per sec. requires a braking force equal to about 80 per cent. of the vehicle weight or about 50 per cent. at 16ft. per sec. per sec. It is clear that the combination of shoe clearance and the lost motion arising from distortion of the linkage imposes a limit upon the mechanical advantage that may usefully be employed. Hence, assuming a maximum comfortable driver's effort of 100 lb., satisfactory braking cannot be obtained by direct manual effort on vehicles exceeding 5000 lb. in weight. In practice, however, vehicles having a gross weight of 19,000 lb. are capable of a satisfactory rate of retardation without power assistance, although, in the author's opinion, at some expense in the matter of the maintenance of the brakes.

The improvements which have made possible this high standard of unassisted brake performance are divided between those directed to the elimination of lost motion in the linkage arising from stress distortion, and the use of self-energising shoe systems. The former constitute an improvement in all circumstances, whereas the latter may, and often does, involve unreliable brake performance by reason of the multiplied effect of changes in the coefficient of friction of the brake linings.

The initial important improvements in the first category were those sponsored and developed by Girling (1930–31) for the mechanical brake and the Lockheed hydraulic system. In the first, torsion is eliminated from the brake system by the provision of wedge-operated shoes and tension rods. By this means it is possible to increase the maximum satisfactory mechanical leverage from about 100/1 to 150/1. The Lockheed system has been widely used on private cars and on many commercial vehicles. The ill effects of the overheating of the operating cylinders contained within the wheels have, however, led to modifications by which the actual operation of the shoes is mechanical, the hydraulic cylinders being situated on adjacent frame members.

In the second category, the Bendix system of self-energising shoes is widely known, and has recently been the subject of further improvement. In the original form of compounded self-energising shoes the torque varied exponentially with the coefficient of friction, and thus gave a very high "shoe factor," but tended to produce unreliable brakes, particularly where the entry of water or oil on to the brake drums was not carefully guarded against. In the ordinary two-shoe brake, cam operated with fixed anchor pins and camshaft, the shoe factor is about 1·6 for the leading shoe and 0·7 for the trailing. The modern version of self-energising shoe arrangement, as exemplified by the two leading shoe design, will give an overall factor of approximately 4, varying directly as the coefficient of friction, and thus tending to more constant action.

The great majority of the goods vehicles falling within and below the 2½ tons unladen weight classification are equipped with unassisted braking systems. The larger of these vehicles are capable of carrying a 6-ton pay load and have a total weight of 19,000 lb. To provide a satisfactory retardation a shoe factor of about 4 and a mechanical advantage of 120/1 are required. These figures are probably representative of the general position. To the same extent that the vehicles below 2½ tons unladen weight are equipped with non-assisted brakes, goods and passenger vehicles above this limit are equipped with power-assisted braking. This definite line of demarcation is the result not only of the theoretical limit of unassisted braking, which has already been stretched to reach so far, but of the artificial limitations of weight and cost. So soon as the field of mass-produced vehicles is passed, power-assisted braking is the rule.

The braking systems of the larger goods and passenger vehicles in Great Britain are almost wholly vacuum operated on the servo principle. Power brakes of the positive type have been practically unknown, although it is probable that some move will be made in this direction during the next few years. In certain cases, which will be referred to later, they have already been tried.

The system most generally favoured includes the provision of a master servo-motor vacuum-operated, and additional vacuum power cylinders on the front axle operated either by the master valve or in conjunction with Lockheed equipment. The master servo-motor generally used is the Clayton Dewandre in which a direct proportion is maintained between the effort exerted by the driver and the assisting force.

The extensive use of the vacuum system has been encouraged in the case of petrol engines by the availability of the induction pipe depression. With the

TABLE IV.—*Relative Merits of Alternative Transmissions*

Feature	Friction clutch and orthodox low-speed gearbox	Fluid transmission	Torque converter
(1) Ease of operation	Some skill required and operation relatively slow. Can be improved for light duty by use of synchromesh.	Good, no skill required. Speedy and certain gear change.	No skill required. Excellent. Speedy and certain gear change, only one operation.
(2) Noise	Good if constant-mesh helical gears fitted and when new. Indifferent on sliding gears and on all gears when worn.	Good at all times	Good at all times
(3) Relative efficiency and fuel consumption	100	97	90
(4) Transmission damping ability	Poor	Good under all conditions	Good when driving through converter. Poor in direct drive.
(5) Performance	Good under all conditions	Good, but imposes limitation for starting on very steep grades in that jerk start cannot to be made.	Good under congested working conditions, not good for high-speed express carriage working. Imposes limitation for starting on very steep grades in that jerk start can not be made
(6) Smoothness of operation and starting	Fair	Good	Very good
(7) Adaptability to full automatic working	Poor	Fair	Good
(8) Ease of providing remote control	Poor	Good	Excellent
(9) Running weight (pounds of relative sliding tooth gearbox taken as 100)	100	163	176
(10) Relative cost	100	270	270

oil engine, however, it is necessary for an exhauster to be employed. This is generally of the rotary vane type and is mounted on the engine and driven from it. The limited capacity of the exhauster renders the use of a storage tank advisable, and thus the simplicity of the vacuum system is already disappearing.

The braking systems in which direct mechanical connection between the driver's foot and the brake shoes is maintained require frequent adjustment because of the limited pedal travel and the direct relationship between the pedal travel and shoe clearance. The Lockheed system, in which automatic adjustment may be effected by the provision of rack-operated travel limit stops, overcomes this difficulty to some extent, but still permits of considerable variation in braking effect arising from the changing angle and hence reduced mechanical advantage of the brake camshaft levers. The frequent necessity for adjustment together with the varying feel of the brake pedal is an undesirable feature, particularly on buses which may be operated by many drivers in one day. To overcome these difficulties entirely, an automatic adjustment system known as the "RP" has been devised, by which the wear of the friction linings is compensated automatically by an adjustment of the brake cam abutment face on the brake shoe. The system is worked by means of a free wheel operated by the shoe movement which rotates a worm gear. This, in turn, operates the threaded brake shoe abutment pad. It works well under some conditions, and is undoubtedly the fundamentally correct method of automatic brake adjustment. The author has had experience of many vehicles equipped with this system which have operated for over 40,000 miles in city working without any attention whatsoever to the brakes. There are, however, certain limitations which must be observed when designing automatic adjustment systems for braking. It is essential that the designed shoe clearance should

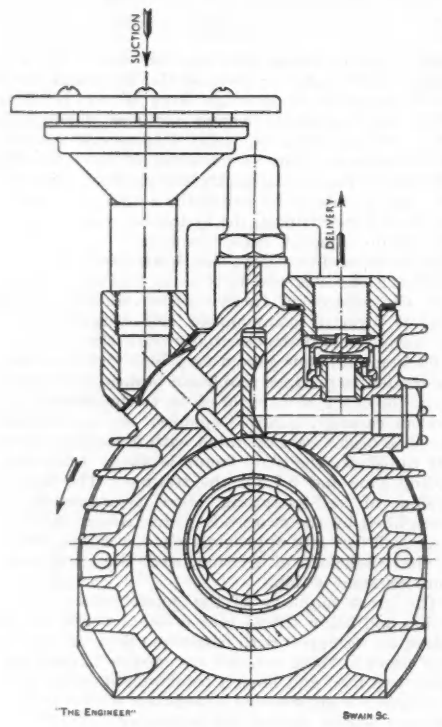
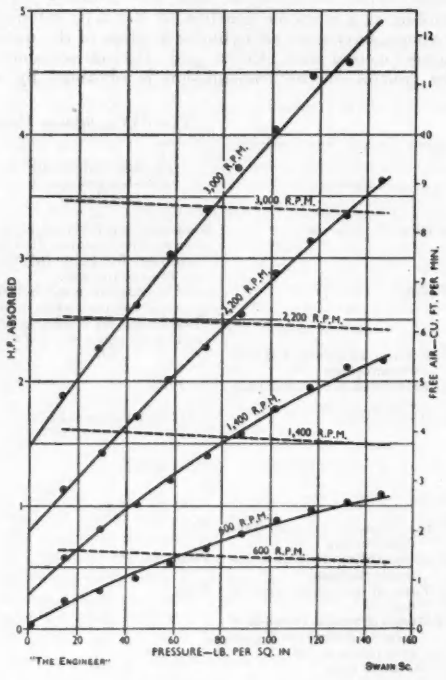


Fig. 9—*Dewandre-Bosch Rotary Compressor*

be sufficient to accommodate not only the normal operating travel, but also drum stretch and expansion. As a consequence of this the hand brake travel is inclined to be excessive under all conditions, and that of the foot brake when hot. This difficulty is sufficient to prevent satisfactory operation under extremes of temperature conditions, or when the service does not require sufficiently frequent hard applications to maintain the adjustment. Experience has shown nevertheless that automatic systems of this type are very satisfactory for urban bus services where a large number of light applications are punctuated by occasional applications of greater severity but short duration.

The increasing need for improved deceleration is beginning to strain the vacuum system, largely because of its limited storage capacity. The pressure is limited to something rather less than that of the atmosphere; in consequence, a greater volume of air must be used, which entails a serious depletion of the reserve available in dense traffic, where the exhauster is rotating slowly and frequent brake applications are made. After much experimental work, the London Passenger Transport Board have now standardised a pressure system using a rotary compressor of the Dewandre-Bosch type. The characteristics of this unit, illustrated in Fig. 9, compare very favourably with those of the piston type. The delivery curve is shown in Fig. 10. The weight of the compressor, together with oil tank, unloader, and separator, is 40 lb.

The vehicles on which this braking system is fitted are double-deck buses of 23,500 lb. gross weight, and are capable of a laden deceleration of about 18ft. per sec. per sec. To obviate the continual use of excessive retardation in service, the controlling



——— Horse-power absorbed. ------- Free air. Swept volume, 100 cu. cm.; working pressure, 80–90 lb. per sq. in.; normal speed, 2500 r.p.m.; maximum speed, 3000 r.p.m.

Fig. 10—*Characteristics of Dewandre-Bosch Rotary Compressor*

valve illustrated in Fig. 11 has a two-stage action. The first stage, with relatively light pedal pressure, is arranged so as to give a maximum retardation of about 11ft. per sec. per sec. The second stage can only be operated by overcoming the resistance of a strong spring and is thus only employed for an emergency stop.

The materials employed for the brake drums are pressed steel for the lighter and less costly trucks, and cast iron for the larger goods-carrying and passenger vehicles. Cast iron possesses a superior resistance to abrasion and exhibits greater freedom from scoring than steel. An analysis which has been found to be very satisfactory is as follows:—

	Per cent.
Total carbon	3·0–3·30
Combined carbon	0·35–0·75
Silicon	1·60–1·80
Manganese	0·40–0·60
Sulphur, less than...	0·10
Phosphorus, less than	0·20
Nickel	1·0–1·20
Chromium	0·80–1·0

The Brinell hardness number of this material is about 200 and the tensile strength 14·0 tons per square inch. This analysis is the result of considerable service testing carried out with many alternative specifications.

Approximately nine years ago the use of solid woven asbestos liners of the asphalt-bonded type with brass wire reinforcement was almost universal. With this material scoring of the brake drums was extremely prevalent. Brake linings of this type were then superseded by the solid-woven non-metallic type impregnated with oil-base resins hardened at high temperature. This type is now in general use. The introduction of this material was followed by an immediate reduction of brake drum scoring, together with an appreciable increase in life. Under certain conditions, where the temperature range is small, the laminated synthetic phenolic resin bonded type of liner, vulcanised under heat and pressure, is capable of giving an extremely low rate of wear of the order of 0·008in. per 1000 miles. It is susceptible, however, to a reduction of the co-efficient of friction at high temperatures, and should not be used in any circumstances where sustained application of the brakes is made. The wear of brake drums and linings in Great Britain has now reached a very satisfactory figure. A double-deck bus, weighing 23,500 lb., having 17in. brake drums and a brake lining area of 430 square inches, will give a rate of wear of 0·011in. per thousand miles on the brake linings and 0·0006in. per thousand miles on the brake drums. These figures correspond to 46,000 miles of operation between changes of brake liners, using ⅜in. brake lining material.

Springing—Wheels and Tyres.—The springing of passenger vehicles, in particular in Great Britain, is largely influenced by considerations of weight. In the case of the double-deck bus, the deflexions are also limited by the tilting test which requires a stability angle of 28 deg. It is found in practice that the fully laden deflexion of the rear springs for double-deck buses is about 4in., and of the front springs about 2in. In some instances, greater deflexions are allowed, but they generally involve a reduction in the upper-deck seating capacity, or, alternatively, the use of high-pressure tyres to enable the stability test to be complied with. The use of stabilisers is prevented by the limitations of maximum weight.

The great majority of road springs are manufactured from silicon-manganese steel, and although in certain instances chrome-vanadium is used for specific high-duty work, it is generally confined to the top leaf of an individual spring and its use is not general. The limitations imposed by weight restriction have tended to maintain the relatively low deflexions which have been cited, since it is impossible to provide sufficient material to obtain a high deflexion at reasonable stress. It is generally found that a satisfactory length of service without failure can only be obtained by stressing the rear springs to about 30 tons per square inch, and the front springs at approximately 20–22 tons per square inch. In these circumstances, it is possible to spring a double-deck bus weighing 10½ tons with about 750 lb. of steel. Where an attempt has been made to employ lighter springs their life has invariably been short.

Considerable improvement in the wear of shackle pins has been obtained by chromium deposition, which appears to be ideal for this work on account of its non-corrosive surface and low co-efficient of friction. A further improvement has been effected by the adoption of automatic lubrication systems which supply the spring pins continuously with lubricant. An automatic lubricator which is being adopted by several large operating companies is the "R.P." This apparatus consists of a plunger operated by the vacuum or pressure of the braking system every time the brake pedal is depressed. A rotating head is provided having twenty-four points, to one of which a small quantity of oil is injected each time the apparatus is worked. At the same time the revolving head is moved so that the next operation may inject oil to the following point. This apparatus provides continual lubrication not only for the shackle pins, but also for other chassis parts hitherto lubricated by relatively infrequent greasing. On account of the extremely high loading of the shackle pin, grease lubrication cannot be satisfactorily employed. This apparatus eliminates the labour of greasing in the garage.

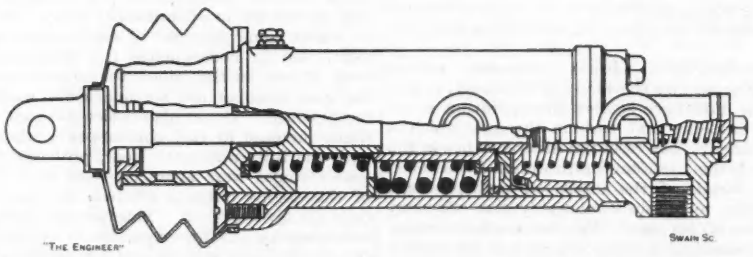


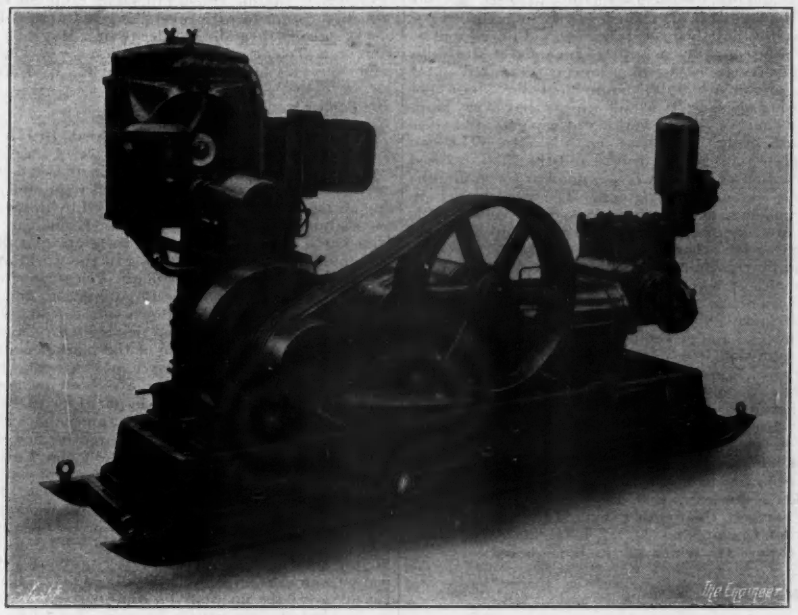
Fig. 11—*Two-Stage Brake Valve used in Conjunction with Air Pressure Braking System*

RECLAIMED ENGINE OILS AND WEAR.—An abstract from a Swedish paper in the Journal of the Institution of Automobile Engineers describes tests which have been made in Stockholm during the last two years on two Chevrolet private cars and four Chevrolet lorries to compare the lubricating properties of new and reclaimed engine oils. It is stated that each of the private cars was run for three 1200-mile periods, using (*a*) new oil, (*b*) used oil reclaimed by a large refinery, and (*c*) used oil reclaimed by an installation at the firm owning the lorries. The cylinder bore wear was measured and corrected to a constant running distance for each period. It was found that, although the bore wear was about three times as great in one car as in another, there was no appreciable difference between the wear with either of the three oils. The four lorries were each run on oils (*a*) and (*c*) only, the wear measurement on the lorries beng confined to the loss in weight of the piston rings during each period. This measurement was also made in the case of the private cars. The mean loss in weight for all rings showed approximately a 10 per cent. increase in the case of the reclaimed oils, but the results were not sufficiently consistent to justify the assumption that there was any significant difference between the lubrication value of the new and reclaimed oils.

Pumping Sets for Oil Field Duty

DURING the past year a number of portable oil-engined pumping sets have been supplied to the Burmah Oil Company by Fowler and Co. (Leeds), Ltd., for general service in the company's oil fields in India and Burma. Amongst them were pumping sets specially ordered for pumping fuel oil. In view of the type of duty which they have to perform the sets have been designed as complete self-contained units, capable of operation on any site, without specially prepared foundations, and of being quickly transported to any given locality.

Each set consists of an oil engine driving through texrope drive a horizontal quadruple-acting power



FUEL OIL PUMPING SET

pump mounted on a combination cast-iron baseplate. The engine is a twin-cylinder Fowler-Sanders unit, rated at 12 B.H.P. at 1000 r.p.m. and incorporating a patented two-way swirl combustion chamber. This class of engine is built essentially for heavy-duty work. The cylinder block and crankcase are cast in one piece, and the counterbalanced crankshaft is inserted endwise. The base of the crankcase forms the lubricating oil sump. Removable cylinder liners of the wet type are fitted, and the cylinder head carries overhead type valves and the combustion chambers. Close attention has been given to dust-proofing; the engine is of the totally enclosed type, having all moving parts, including the C.A.V. fuel injection pump, protected by oil-tight dust-proof covers, which are, however, easily removable so that accessibility is unimpaired. A further protection against dust-laden atmosphere is provided by the fitting of an oil-wash air cleaner on the air inlet to the cylinders. Radiator cooling is employed, a radiator of tropical capacity being mounted directly on the engine. A fuel tank of sufficient capacity for 7 hours running at full load is mounted on the engine. Starting is by hand, a patented decompressor gear being incorporated.

Mounted on the same baseplate, and driven by the texrope drive through a centrifugal clutch, is a horizontal quadruple acting duplex power pump made by Joseph Evans and Sons (Wolverhampton), Ltd., suitable for handling fuel oil. The pump has barrels 1¼in. diameter by 5in. stroke, and has a crankshaft speed of 70 r.p.m. with a countershaft speed of 280 r.p.m. The inlet and outlet branches are of 2in. diameter. The pump is fitted with an air vessel, a pressure gauge, and suction and discharge valves of the flanged full-way type. The baseplate is mounted on special steel skids to facilitate transport.

The Burmah Oil Company has also taken delivery of similar sets, designed and built by Messrs. Fowlers, but intended for water pumping service. The general design of these water pumping sets follows the lines of the fuel oil sets described above, but the modifications necessary on the pumps for the handling of fuel oil are omitted. These sets are also fitted with steel skids and are designed as portable self-contained units.

Sixty Years Ago

THE STORY OF AN IRISH ENGINEER

JOHN MACNEILL, son of Torquil MacNeill of Mount Pleasant, Louth, was born about 1793. He seemed destined, like the cadets of most Irish families at that time, for the profession of arms and was actually gazetted as an ensign in the Louth Militia. The battles of Leipzig and Waterloo however changed his fate. The interest of friends secured him an introduction to Thomas Telford and he became an engineer. Telford, it seems, thought highly of the handsome young Irishman and appointed him as one of his "deputies." MacNeill's opportunities for self-education as an engineer while employed under Telford between 1820 and 1830 were great, and he pursued them energetically. After Telford's death in 1834 MacNeill set up in business on his own account in London with an office also in Glasgow. His chief interest was railway engineering and, pursuing it, he executed the Wishaw and Coltness Railway, and some other minor lines in Scotland. Ireland, however, still tugged at his heart and he always regarded Mount Pleasant as his home. In time he returned to his native land in anticipation, no doubt, of using his professional knowledge in aid of the railway development of the country. It was, however, a distressful period of Irish history and the time for the construction of great trunk lines had not yet arrived. MacNeill turned his attention to the limestone deposits near his ancestral home and established lime burning works from which he supplied the neighbouring farmers with the means of improving their poor soil. For a period the works prospered, but later when the construction of the railways brought competition, the prosperity of the works gradually dwindled. A second commercial enterprise on which he embarked at a later stage in his career met with a fate sudden and decisive. Influenced by a campaign for the extension of flax growing throughout the whole of Ireland he built a very complete flax manufactory at Mount Pleasant. Within a few weeks of the starting of these works they were totally destroyed by fire. Of MacNeill's activities as an engineer in Ireland we will mention three which we take from his obituary published in our issue of March 19th, 1880, a fortnight or so after his death. Efforts made to establish in Dublin a great technical college on the lines of the Ecole Centrale at Paris aroused the board of Trinity College to activity and led to the decision to establish a school of engineering within the college. MacNeill was put forward as professor and in that capacity his name was prominently associated with the school for some years. His professional work, and the imperfection of his theoretical knowledge, prevented him however from exercising his professional duties in the normal manner, and Professor Downing was appointed to act as his *répétiteur*. MacNeill was closely connected with the construction of the first railway line in Ireland, the Dublin and Kingstown railway. It was he who chose the 5ft. 3in gauge. One of the works on the line which he designed was a bridge across a canal near Dublin. It was intended to be a lattice girder bridge on the principle which had recently been developed in Germany. MacNeill, however, apparently failed to grasp the essentials of the design. Certain vertical and horizontal members required to complete the triangulation were omitted and when the scaffolding beneath the bridge was removed it sank about 18in. at the centre. The bridge was, in fact, as flexible as a pair of gigantic "lazy tongs." It was forced back to its original alignment and held there by riveting on a heavy plate which converted its design into a cross between the lattice and a suspended truss. At a later period MacNeill was in charge of the construction of the Great Southern and Western Railway. The Lord Lieutenant and his suite arrived at Kildare to perform the opening ceremony of the first portion of the line. When, however, they tried to leave the railway carriages it was found that the station platform was three or four inches too high to permit the doors to be opened. From this railway prison the parties were released not by shunting the train clear of the station as one might expect, but by sending a number of navvies beneath the coach to lift it upwards on their backs.

Canadian Engineering News

(By our Canadian Correspondent)

Industry and War

ANY talk about profiteering in industry in Canada has already received its answer. The prompt and zealous response of industry to Europe's challenge and Britain's urgent needs, and the spontaneous moves of various branches of organised industry to prevent abuses prevalent in the last great war, are a silencing reply to apprehensions. Makers of shells and shell casings, makers of planes and parts and other vital war materials have on their own initiative imposed conditions on their own operations that will not only ensure prompt delivery but also efficient production and minimum profits. The export of certain valuable minerals has been banned. This will affect nickel, amongst other essential war materials. Exports of nickel to the United States in the first eight months of the present calendar year were more than double those of last year, but it is believed some of this found its way to Japan. Exports direct from Canada to Japan in the first six months of 1939 amounted to 4,609,621 dollars compared with 2,586,248 dollars in the corresponding period of 1938.

In the case of scrap iron and scrap steel no licences for export will be granted, which means an embargo on their shipment abroad, with the notable exception of Britain, while France may be accorded similar treatment as Britain's ally. An important feature of this policy is that for the first time the movement of scrap iron and scrap steel to Japan, as well as Germany, will be stopped. Japan has been purchasing large quantities of scrap iron from Canada, as well as from the United States. But Japan is to be allowed continued access to Canada's nickel supplies, and any attempt at stopping nickel exports to Japan would probably be interpreted by Tokyo as an unfriendly act, and, moreover, it is doubted if such an embargo would be of any use unless the United States were to co-operate and see that Canadian nickel purchased in Canada by Americans was not forwarded across the Pacific.

Trend in Equipment

How the development of railroad motive power in Canada has changed manufacturing conditions was shown by figures issued recently by the Department of Commerce. Of the 196 locomotives ordered in this country in the first eight months of the year, 154 were oil-electric and only 16 were steam. The locomotive manufacturers, of course, are prepared to build both kinds of engines, but if this trend continues, there will be a chance that many manufacturing devices will be left idle. One explanation is that steam locomotives have a long-period life. By keeping them in repair and adding improvements as they are developed, the railroads have been able to hold steam locomotive purchases to a minimum in recent years. The manufacturers contend that this practice is uneconomic, but the railroads persist in it.

Anti-Noise Precaution

To overcome the difficulty of rattling manhole covers, in Forest Hill, Ontario, where there is an anti-noise by-law, a machined steel template the size of the cover was used to locate high spots on the seat of each frame, followed by the use of a compressed air-operated grinder to remove unevenness from the frame and cover. Where a proper fit was obtained a mark was made on the frame and cover, so that if the cover had to be lifted it could be returned to its proper position. A considerable number of frames and covers were ground in this manner, but within a year some of them were rattling again. No doubt, much of the trouble was due to hard particles lodging on the seat, but there was also proof of a change in shape or size, caused either by warping of covers owing to temperature changes, or "growth of metal" due to weathering. Grinding frames and covers having proved unsuccessful, they were then packed with burlap, which eliminated the rattling for a few months. About three years ago the municipal authorities commenced using a patented tape-like packing known as "Tapax," which, being sticky on one side, adhered to the manhole frame, but allowed the cover to remain loose. The frame is first cleaned with a wire brush and then with paraffin to make sure that the "Tapax" will stick. The cost for labour and material is about $2·25 per manhole. For all new manholes a "non-rattling" type of frame and cover is now used, which is a modified form of one used in the City of Montreal. The new frame and cover weighs 470 lb., which is about 70lb. heavier than the type formerly used. The cover has deeper ribs to resist warping, and the surface which rests on the seat is corrugated. The frame seat is fluted vertically, so that a half-turn of the cover in the frame will move particles of dirt, etc., to the flutes, and thence down into the sewer.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

The Continental Steel Trade

For the duration of the war the Continental steel trade may be regarded as including only Belgium and Luxemburg, since the belligerent countries are not in a position to pay much attention to exports. The steelmakers in these two countries are experiencing keen disappointment at the failure of the recent inquiry from overseas to materialise into business. About ten days ago it appeared that overseas markets were on the verge of a substantial buying movement and some considerable tonnages of the usual commercial descriptions of iron and steel were inquired for. For some reason which it is difficult to discern the inquiry subsided as quickly as it had arisen and only a moderate tonnage of orders resulted. The mills on the Continent, however, are not badly off for work, particularly in Belgium. The estimated production of iron and steel in that country for January last has been published and shows a considerable increase when compared with January, 1939. The Belgian production of pig iron, for instance, was 305,200 metric tons, against 231,000 tons in January, 1939, whilst the figure for ingots was 315,500 tons compared with 204,000 tons a year ago, and for finished steel 201,000 tons against 162,000 tons in January, 1939. The principal concern of the Belgian steelmakers for the time being is the persistence and strength of the competition from the United States. Not only have orders been taken from the Continental mills in the Far East, the Near East, and South America, but substantial business has been lost to the same competitors in Holland and Scandinavia. Some idea of the competition can be gathered from the fact that Belgian consumers have actually placed orders with American makers as apart from the price being more favourable they were also able to obtain earlier delivery. Both in Belgium and Luxemburg the view is taken that this competition must be sporadic in character, and that a return to anything like normal conditions would show that the Continental works could hold their own. Germany, of course, is out of the export markets, but it is reported that she is bartering some of her much needed production of structural steel and merchant bars for Swedish iron ore and machinery. Neither Great Britain nor France have any important quantities of steel for export owing to their own huge war requirements. In France it is expected that iron ore prices will be advanced shortly, and it is conceivable that this may lead in the not distant future to a general increase in French steel prices. An interesting arrangement has been reached between the Governments of Spain and Portugal by which the Spanish steel industry is to supply Portugal with several thousand tons of various descriptions of steel each month over a period. This has come as disappointment to the Belgian and Luxemburg makers who regarded the Portuguese market as their own.

The Pig Iron Market

In the basic iron department it has been necessary to import considerable quantities to maintain the steelworks in full operation. This is partly because the scarcity of scrap has led to the use of larger quantities of pig iron. In the foundry iron section conditions are as comfortable as could be expected in wartime and far more so than appeared probable at the outbreak of hostilities. The production of high phosphoric pig iron is on a moderate scale, although probably it is sufficient to take care of consumption. The light castings foundries are the largest consumers of this description and most of them are working short time—although there are exceptions to this—owing to the decline in building operations. Efforts are being made to find a place for these foundries in our war economy, and orders have already been placed which have materially improved the position of some of the works. On the North-East Coast the production of foundry iron has practically ceased and the whole blast furnace capacity is engaged on the production of steelmaking irons. The foundries in this district, however, appear to be adequately catered for by the Midland blast furnaces, and there is some speculation as to whether the output of Cleveland iron will ever be resumed on its former scale. The Control seems to be taking adequate precautions in issuing licences to prevent any accumulation of stocks, and this is accepted by consumers as a necessary wartime measure. The Midland pig iron producers are operating at capacity and the output is passing immediately into use. Such stocks as exist either at the foundries or in the hands of consumers are negligible. The demand for high phosphoric pig iron remains poor, but, on the other hand, the call for low phosphoric iron which is chiefly used by the engineering foundries is somewhat in excess of the supply. Practically all consumers are employed upon Government work, but even so they find it difficult to obtain some of the special grades of iron which they have been accustomed to use. One result of the war may be to faniliarise consumers with the use of types of iron which they had hitherto considered unsuitable for their particular class of work. In Scotland consumers are getting all the iron they require, but there does not seem much surplus for purposes not concerned with the national war effort. Most of the foundry iron produced is going to the engineering foundries, and the needs of the light castings industry are comparatively small. Pressure to secure supplies of hematite is unrelaxed, and with the stocks at the works largely depleted some delay in delivery has been reported. The Control, however, appears to be maintaining an equitable distribution and there are no real difficulties arising from this cause.

The Midlands and South Wales

Whilst production at the Midland steelworks is maintained at a high level, arrears in deliveries are accumulating. This is not the result of any restriction in output, but is due to the constantly increasing demands for all descriptions of iron and steel. Practically all the orders now accepted by the steelworks have claims to priority and the position now is that the makers have to select those which are the most urgently required by Government Departments. As fresh work of this description keeps coming forward there is an increasing tonnage of orders awaiting fulfilment, in spite of the fact that the makers are reluctant to take on new business except under pressure. The consuming trades almost without exception are fully engaged upon work arising directly or indirectly from the war. This applies with particular force to the constructional engineering firms who have an immense amount of work in hand and whose requirements of joists and sections and other sorts of structural material amount to a huge tonnage. It says much for the organisation of the steel trades that their needs are catered for as well as they are. The steadily mounting demands of the shipbuilding industry are occasioning some concern, but so far at any rate urgent Admiralty requirements have been met to a surprising degree. It would appear that every shipyard in the country is now working at capacity and their demands are likely to increase considerably. The call upon the plate mills is also heavy, and the time required for the execution of an order is about six or seven months and shows a tendency to lengthen. The sheet works are also experiencing active conditions and considerable quantities are required in connection with ship construction as well as for other war purposes. Little attention can be paid by this industry to the export demand owing to the pressure of home needs, and there still remains a considerable tonnage of pre-war export orders to be completed. In South Wales there is no relaxation in activity at the steelworks and the consuming works. Complaints are heard from the latter of the difficulty of obtaining full supplies of steel, and this is attributed to a great extent to the inability to obtain sufficient quantities of scrap. Latterly, however, arrivals from the United States have somewhat eased the position. A slackening has been noticeable in the overseas demand for tinplates, and at the same time home requirements appear to have declined. So large is the tonnage of orders on the books of the tinplate makers, however, that this pause in business is welcomed rather than otherwise. The official home quotation for tinplates is 24s. 9d. f.o.t., 20 by 14 basis; whilst for export 31s. 6d. to 32s. f.o.b. is quoted.

Scotland and the North

The slight recession in the volume of new business in iron and steel which has been transacted in Scotland is attributed more to the difficulty which consumers find in placing their orders and the impossibility of arranging for reasonable delivery than to any shrinking in requirements. All the principal iron and steel consuming industries have enough work in hand to keep them employed for several months, and are exerting great pressure upon the steelworks to obtain supplies. The latter, with over-loaded order books, are in no position to accelerate deliveries. Material urgently required by the services is, of course, receiving due attention, but apart from this an order must have strong backing and some special feature before any promise of execution in less than several months can be obtained. The demand for shipbuilding steel has increased during the last week or two as a result of the programme of naval and mercantile construction which has been put in hand by the Government. Heavy tonnages of plates and sections are passing into use at the Clyde yards, and there is an incessant pressure on the part of this industry to secure fresh supplies. At the same time, there has been no relaxation in the demands of the constructional engineers, who have an enormous amount of work in hand in different parts of the country in the way of erecting new munition works and making extensions to existing premises. In these conditions it is not surprising that a stringency is arising in the supply of structural steel. In some cases deliveries of new work cannot be promised for seven to eight months, and it is difficult to see any direction in which this position can be improved. It is expected that arrangements will be made for importations of foreign steel which should ease the position and afford relief both to producers and consumers. In the sheet industry the position is rather easier; but the stringency in the supply of steel has a restrictive effect upon production. Nevertheless, large tonnages are being turned out and are immediately passing into consumption. Export business is being done upon only a small scale. In the Lancashire district great pressure is being exercised by consumers to obtain deliveries of all classes of steel. The volume of new business has declined chiefly because of the difficulty of placing orders which are not of an especially urgent character. The powers of absorption shown by the constructional engineering industry in Scotland are extraordinary, and some complaints are heard of arrears in deliveries from the steel works of joists and sections. The wire works are also experiencing a heavy demand and business in tool steel, special and alloy steels is at a high level. On the North-West Coast the works are fully occupied and likely to remain so for several months.

Overseas Trade Opportunities

The Department of Overseas Trade, Great George Street, London, S.W.1., announces that the following contracts are open for tender. Local representation is essential in all cases. Indian Stores Dept.: Supply and delivery of quantities of steel boiler tubes required for the E.I. and G.I.P. Railways (New Delhi, March 26th); quantities of steel springs for railways, including spiral for engine and tender, spiral bogie check, spiral for brake gear, buffer plunger, draw hook, &c. (New Delhi, March 27th). South African Union Tender and Supplies Board: Supply, delivery and erection of refrigerating plant at Johannesburg Police Mortuary (Pretoria, March 28th). Administration of Orange Free State: Supply and delivery of deep well pump heads and engines capable of pumping from a depth of 150ft. with a capacity of between 1000 gallons and 1500 gallons of water per hour (Bloemfontein, March 29th). Argentine State Oilfields Department: Supply and delivery of quantities of files of various types and sizes (Buenos Aires, March 29th). South African Railways and Harbours Administration: Supply and delivery of quantities of steel plates (Johannesburg, April 1st); pipes and fittings required for Table Bay Harbour (Johannesburg, April 15th); one 42,000-gallon pressed steel tank 32ft. by 8ft. deep, open top; quantities of grinding wheels (Johannesburg, April 18th); one 15-ton electrically driven Goliath crane (Johannesburg, April 22nd). Egypt, Ministry of Public Works, Cairo: Supply and delivery of two 60 H.P. marine Diesel propelling units for two motor launches, complete with reversing gear, stern tube, thrust block, stern shaft and propeller (Cairo, May 1st). Rabat, Moroccan Telephone Administration: six lots of miscellaneous galvanised ironwork (Rabat, April 3rd).

Copper and Tin

The copper position in Great Britain has not shown much change for several weeks. Recently, however, the demand appears to have increased but supplies have been fully equal to covering all requirements. Disappointment continues to be expressed by dealers that the negotiations between the Metal Exchange and the Ministry of Supply with a view to re-opening the market have made such little progress. In the world market the position is somewhat irregular. Prices in the United States are firm, the domestic quotation being 11·50c. Although buying has died down to a considerable extent there is a fairly good business passing with American consumers. On the export side of the market neutrals have not bought with so much freedom as a week or two ago, although Italy and Sweden have been in the market. Russia also is reported to have inquired for 10,000 tons and to have been willing to pay something above the official export quotation of 11·60c. Apparently, however, there is general reluctance on the part of the United States manufacturers to sell to the Soviet Government. Turkey has been inquiring in the market for about 3000 tons. The impression seems to prevail that American consumers are well bought and that in spite of the steady demand which is ruling at the moment there will be no important buying movement until the heavy purchases during the last two months have been worked off. . . . Prices in the tin market have fluctuated within narrow limits over the week; but the general tendency has been firm. For the time being there seems to be no scarcity of tin but the recent cut in the export quota by the International Tin Committee may result in a more stringent position developing in two or three months. The exchange regulations recently introduced have had little effect on the market beyond increasing the price in the United States of English and Straits tin. Rather quiet conditions have developed in the United States market and for the time being at any rate consumers there appear to have covered their requirements. It is reported that arrangements are likely to be made to increase the smelting capacity in the Dutch East Indies to deal with the whole output of Banka ore on the spot. Apparently this has been decided upon in view of the transport difficulties which have arisen as a result of the war.

Lead and Spelter

Satisfactory conditions continue to rule in the British lead market. Supplies are being well maintained and are sufficient to cover the high consumption of the metal for war purposes. The quantities available, however, are not so abundant as to enable liberal releases to trades which are not concerned with war work. It is suggested that the position might possibly be difficult if it were not for the recession in building trade operations which, of course, has been reflected in a smaller demand for a number of lead products. Whether more open weather will bring about an increase in building programmes and a consequently heavier demand for lead remains to be seen. It is noticeable that little grumbling is heard by consumers with regard to brands. All the lead distributed is Empire metal, with which little complaint can be found, but no doubt some users would be quite prepared to take the cheaper foreign lead if it were available. Stocks, however, which were in this country at the beginning of the war have by now been much depleted. Foreign lead is going to neutral markets and some of the latter are no doubt benefitting from the limitation of supplies of lead for the manufacture of products for export. A little trade is being done by British manufacturers of lead products with overseas markets, but naturally there is not much metal available for this purpose. . . . A strong demand for spelter has developed in the British market and the supply position is somewhat tighter than in the case of lead. Practically all the available supplies of the metal are being used for war needs, and the deliveries seem to be sufficient to enable the consuming works to operate full time. If the situation should become more stringent there would be no difficulty in obtaining further supplies of foreign spelter, but so far there has been no suggestion that this is necessary. Several industries are working at great pressure, including the brassmakers. The galvanisers also are taking large quantities and are likely to continue to do so since the sheet mills have full order books.

OXYGEN AND NITROUS OXIDE CYLINDERS.—Earlier appeals which the Ministry of Health has made to users to refrain from hoarding oxygen and nitrous oxide cylinders met with an excellent response. As, however, increased demands for these cylinders are again taxing the available resources, it is necessary to issue a further reminder that the quantities held should not be in excess of actual requirements, and that empty cylinders should be returned to the suppliers without delay. Only if this is done can the limited supplies available be used to the fullest advantage.

French Engineering Notes

(From our own Correspondent in Paris)

Export Facilities

As an essential element of national defence the Government is preparing an organisation to facilitate export trade in every way compatible with precautions that have to be taken during an economic war. Little can be exported without simplifying the mass of formalities that have to be gone through to obtain import licences at a time when imports are technically prohibited, as well as export licences which are necessary to avoid the possibility of goods reaching an enemy country, while both imports and exports are subjected to strict exchange control. As the matter now stands, the only encouragement offered to manufacturers to concentrate on export trade is the removal of profit limitations imposed on all goods except those sold abroad, but makers must also be able to procure raw materials and men, and more must be done than heretofore to ensure these supplies. Since the operation of the Franco-British commercial agreement the procedure has been simplified in respect of Great Britain, and the question of foreign trade is now being dealt with as a whole by a proposal of the Minister of Commerce which will probably have become law before these notes are in print It is intended to create a Superior Council of Foreign Trade comprising heads of the following departments:—Production and foreign trade at the Ministry of Commerce, Ministries of Finance, Customs, Blockade, Colonies, Merchant Marine, and the National Economy, to whom will be added six commercial and industrial representatives who will be invited to offer suggestions for developing trade abroad. The executive work will be undertaken by a number of technicians representing different branches of industry, each of whom will have an intimate knowledge of his particular branch and will always be in close contact with its Chambre Syndicale and with exporters. The duties of these technicians are to keep themselves fully informed of export orders and contracts in hand and to arrange for the supply of necessary materials to execute them and provide all information and papers needed to obtain visas for export. The manufacturer will no longer be worried and delayed by formalities. He has merely to fill in the papers. A serious hindrance to export trade are inadequate facilities for transport through increasingly heavy burdens imposed on the National Railway Company by military requirements. The "export service," as the new organisation is called, will obviate these difficulties by means of a dispatching service which will co-ordinate consignments in a manner to ensure goods being sent to ports of shipment and loaded on board with the least possible delay. It is made clear that this State organisation does not aim at any kind of industrial nationalisation and is intended merely to guide and assist exporters.

Naval Construction

The Minister of Marine, Monsieur Campinchi, states that 126 naval ships are now under construction, including the four 35,000-ton battleships. The "Richelieu" will be in service this year, and the "Jean-Bart," which has just been launched, will be ready next year, while the "Clemenceau" and "Gascogne" will go into service in 1942. The aircraft carriers "Joffre" and "Painlevé" are being completed. It is expected that the three cruisers "De Grasse," "Châteaurenault," and "Guichen" will join the fleet next year. The four 3000-ton destroyers "Marceau," "Kléber," "Desaix," and "Hoche" are under construction, as well as eleven torpedo boats of 1772 tons of "Le Hardi" class, fourteen 984-ton torpedo boats intended principally for the protection of convoys, five submarines of 1500 and 1600 tons, fifteen submarines of 669 tons, and three minelaying submarines, besides a number of mine sweepers, and other light craft.

Labour Emergency Measures

A natural consequence of industrial expansion is a migration of labour from rural areas to manufacturing centres where wages are higher, work is less arduous as a rule, and more social inducements are offered. In a country where agriculture is the staple industry, upon which depends directly one half of the population, the migration of land workers since the last war is a serious matter. Governments have tried vainly to stem a movement that threatens the existence of a vital national industry. Manufacturing industries absorb workers in a manner that can only be avoided either by placing agriculture on the same plane as manufacturing trades with higher wages and easier conditions of work or by separating the two and preventing migration from one to the other. It had been hoped to do something with the former alternative by giving a more general mechanical character to agriculture whereby workers would be classed as mechanics instead of labourers. It depends upon the ability of the agricultural engineer to solve satisfactorily many varied and difficult problems whether agriculture can be made more attractive and profitable to land workers. Now that the factory and the farm are both required to work to their utmost, and both are needing more hands, the Government has decided to use its powers of labour control to adopt the second alternative and decree that land workers must remain on the land. Agricultural labourers who went into armament factories will return to their former occupation. Industrial employers are now debarred from their chief source of labour supply, so far as concerns specialised workers who are easily and quickly trained for particular jobs, and they can only look to the extensive apprenticeship organisation to provide skilled hands in the future and, for their immediate needs, to women who are morally conscripted for any work that can be undertaken by them. They have proved themselves adaptable to ordinary machining, fitting and erecting, and it seems that, however long the war may last, there will be no difficulty in carrying on production. This, of course, is a war-time measure that will cease with the end of the war, but the problem of conciliating the labour demands of agriculture and industry will remain in a less acute form, and the experience now being acquired should be useful in suggesting some practical means of regulating the labour supply in a manner which will satisfy both industry and agriculture.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

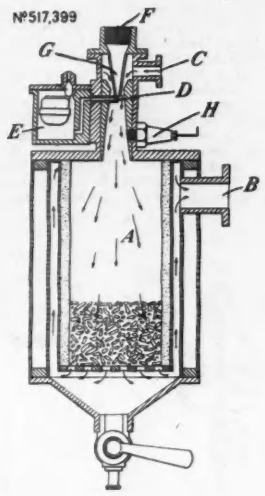
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES

517,399. July 26th, 1938.—VAPORISERS FOR INTERNAL COMBUSTION ENGINES, Société Industrielle Hellénique des Gazofacteurs "Berhoudar" S.A., a Greek company, 14, Boulevard Syngros, Athens, Greece.

This invention relates to an apparatus for producing combustible gases from heavy hydrocarbons, such as, for example, mazout, schist oil, vegetable oils, and the like, for internal combustion engines chiefly in motor-cars and like vehicles. The apparatus comprises a cylindrical chamber A coated internally with refractory material. The bottom of the chamber is perforated, and it is charged to a certain level with refractory porous material, such as pumice-stone, which may be impregnated with catalytic material such as nickel. The chamber is surrounded by a double-walled casing forming a heat insulator. The casing is closed at its lower end with a cone-shaped cover provided with a central orifice closed by a drain cock. Between the internal wall of the casing and the wall of the chamber an annular space is left for the gases formed to pass through. This space has at its upper portion an outlet B which is connected with the inlet manifold of the engine. The chamber and the casing are attached to a cover which communicates through an orifice C with the external air and forms a venturi tube. Into the extension opens an orifice D connected to a constant level receptable E for the heavy hydrocarbon. At the upper extremity of the cover is provided a joint F connected with a branch of the exhaust pipe of the engine, the joint carrying

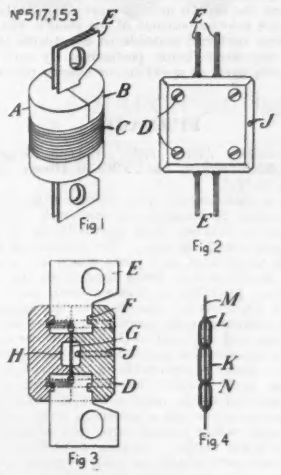


at its lower end an ejector nozzle G reaching exactly above the orifice D. A little below the orifice, on the cylindrical extension, is a sparking plug H to ignite the mixture of combustible oil with air. The apparatus is placed between the reservoir of heavy hydrocarbon to be cracked and the engine, and its operation is as follows:—Owing to the suction of the engine—which is first run for a few seconds on petrol—a reduction of pressure is produced in chamber A and at the same time part of the exhaust gas is forced through the nozzle G past the orifice D, carrying with it some of the heavy hydrocarbon, proportional to the suction of the engine, the heavy hydrocarbon being thus dispersed in fine cloudlike particles in the chamber. At the same time a certain amount of external air is drawn in through the orifice C and mixes with the atomised hydrocarbon. This mixture of hydrocarbon with air on reaching the sparking plug becomes ignited and heats the chamber walls and the refractory porous material. The calibrated air inlet into the venturi tube is regulated so that the amount of air admitted is just enough for the combustion of only a small amount of the atomised hydrocarbon in the chamber. The rest of the hydrocarbon introduced is transformed into a gas by the heat chamber. In this form it is easily cracked under the influence of the ignition flame. The heavier cracked products before traversing the perforated bottom of the chamber pass through an incandescent layer of refractory, porous material and thus undergo further cracking. The cracked products pass through the perforated bottom and the annular space to the outlet, and from there through a suitable purifier to the inlet manifold of the engine.—*January 29th*, 1940.

ELECTRICAL APPLIANCES

517,153. August 23rd, 1938.—IMPROVEMENTS IN ELECTRIC FUSES, Gordon Spencer Marston and J. G. Statter and Co., Ltd., both of 16, Great George Street, Westminster, London, S.W.1.

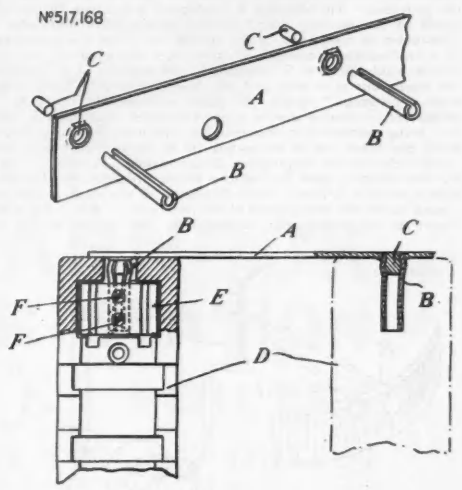
The cover of the fuse, described in this specification, is composed of two parts A and B which are joined in Fig. 1 by an insulated binding wire C and in Figs. 2 and 3 by screws D, the plane of division in Fig. 2 being parallel to the plane of the paper. Contacts E fit in grooves in the parts A and B, and are secured by shoulders F against being blown out. A fusible element G shown in Fig. 3 as a wire is attached, for example, by soldering to each pair of contacts E. The element G passes through a cavity H in the cover A, B which may contain chemically treated sand to prevent ignition when the element fuses. In the fuse shown in Figs. 2 and 3 a signal plug J of known construction, and adapted to be blown partly out of the fuse when the element melts, communicates with the cavity H. Instead of being a wire, the fusible element may be a tube of silver, lead, or another suitable metal, for example, a silver-plated copper tube. An especially advantageous element is a closed tube filled with an insulating non-inflammable liquid, for example, carbon tetrachloride, or a powdered solid, for example, sand, through which passes a fuse wire. An element of this kind is shown in Fig. 4. The tube K is pinched at each end L so as to be liquid-tight, to a fuse wire M, after having been filled with carbon tetrachloride. Fusing is localised at, or near,



the centre by spinning the tube as shown at N.—*January 22nd*, 1940.

517,168. May 21st, 1938.—IMPROVED METHOD OF MAKING AN ELECTRICAL CONNECTION WITH A CURRENT CONDUCTOR, Wm. Sanders and Co. (Wednesbury), Ltd., Ridding Lane, Wednesbury, Stafford, and William Preston, of the Company's address.

The bus-bar A comprises a strip of copper pierced at each position at which a fuse is to be mounted with a hole, the periphery of which is of a substantially D-shape. The hole is formed by a tool which produces a slight truncated projection on the side of the bus-bar on which the fuse bases are to be located. Each hole is adapted to receive an end of a connecting member in the form of a length B of copper sheet which is rolled to an arcuate form, with a gap between edges. A rivet



C is then passed into the bore of the rolled member and caused to expand the walls into firm contact with the wall bounding the hole. The head on the rear side of the bus-bar fills in the depression produced by the formation of a truncated projection. The base D of each fuse is provided at each end with a cut-away portion which registers with the end of a terminal block E having the usual slots for engagement with the blades of the removable section of the fuse. The central portion of the terminal block has an axial hole of slightly greater diameter than the external diameter of the member B. The wall of the block is provided with two tapped holes, at right angles to the axial hole, which accommodate screws F with pointed ends. The points of these screws engage in the gap in B and force the wall into firm contact with the axial hole in the terminal block.—*January 23rd*, 1940.

TRANSMISSION OF POWER

516,908. July 29th, 1938.—ELECTRIC CABLES, Pirelli-General Cable Works, Ltd., of 343/5, Euston Road, London, N.W.1, and Herbert Trowbridge Werren, of 45, Maresfield Gardens, Hampstead, N.W.3.

This invention applies to electric cables of the kind comprising inner and outer conductors arranged in co-axial relationship to one another and usually maintained in such relationship by spacers of insulating material. In such cables it is common practice to enclose the conductors within a lead or lead-alloy sheath, and it has also been proposed to surround this sheath with iron or steel armouring. There are, however, numerous advantages which accrue from the use of a sheath of a material other than lead or its alloys, providing, of course, that the sheath of such other material performs the essential functions of lead or like sheaths as at present employed. According to the invention, in an electric cable of the kind comprising inner and outer conductors arranged in co-axial relationship to one another, the sheath surrounding the outer conductor is made of steel, it being understood that the term "steel" is to be regarded as including iron. Several advantages accrue from using steel as a substitute for lead or lead alloy for the sheath in a co-axial cable, among which may be mentioned the fact that, under normal conditions of use, the steel sheath maintains its truly cylindrical shape apart from any support from the internal spacers of insulating material; such spacers are called upon solely to perform their function of maintaining the inner conductor concentric with the outer conductor. As in the case of the outer conductor, the steel sheath may take the form of a strip which is wound on helically or is applied longitudinally to form the sheath. In either case the operation may be effected by means of suitably shaped rollers and the apparatus may be designed to apply a strip of copper or other appropriate material constituting the outer conductor simultaneously with the steel sheath. Further, at the same time the edges of the strips may be welded together to form respectively the outer conductor and the sheath, and also the

strips may be welded to each other. If the spacers employed to maintain the inner conductor concentric with the outer conductor be of thermoplastic material, a layer of heat-insulating material may be provided to prevent their deformation during the welding operation. As an alternative, the steel strip which is to constitute the sheath may be provided on that face which will become the internal surface of the sheath with a deposit of copper or other material suitable to constitute the outer conductor, the deposition being performed by any of the well-known methods such as spraying or electro-plating.—*January 15th*, 1940.

FURNACES

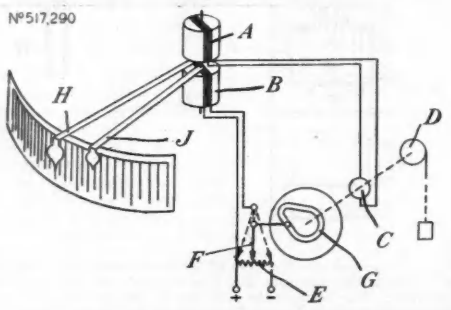
517,007. October 25th, 1938.—WATER-COOLED FURNACE PORTS, Blaw Knox, Ltd., Clifton House, Euston Road, London, N.W.1.

The water-cooled furnace port construction according to the present invention is adapted for use with various types of furnace ports, but it is especially applicable to the gas ports of a reversible open hearth furnace. The nozzle end and the lower edges are the portions of such ports which are most exposed to gases when the furnace is being fired from the opposite end. The invention provides a water-cooled port construction comprising a main cooler extending to the nozzle end of the port and an auxiliary cooler associated therewith, the auxiliary extending along and adjacent to the main cooler and adjacent to the end of the main cooler situated at the nozzle end of the port. The auxiliary cooler is preferably in the form of a pipe and it comprises an arch portion having two leg portions. The auxiliary is secured to the main cooler in such manner that its arch lies adjacent to the end of the main cooler at the nozzle end of the port, and its legs extend along and adjacent to the lower edges of the main cooler. In this way, the portions of the main cooler and port which are most exposed to the hot gases of the furnace are protected by the auxiliary cooler. Water or other cooling fluid is passed first through the auxiliary cooler and thereafter through the main cooler. Thus, the coldest water is supplied to the hottest parts of the port and the water which has been somewhat heated thereby is then supplied to the main cooler, the body portion of which is not subjected to as hot gases as are the bottom edges and end of the main cooler at the nozzle end of the port.—*January 17th*, 1940.

MINING MACHINERY

517,290. July 18th, 1938.—INDICATING DEVICE FOR USE WITH WINDING GEARS, English Electric Company, Ltd., Queen's House, 28, Kingsway, London, W.C.2, Albert Ernest Rogers and Harry Hawley Begent, both of Siemens Works, Stafford.

The device is illustrated in the accompanying drawings in which two electro-magnetic instrument movements A and B are provided. The element A is adapted to indicate the actual speed of the winding gear and may conveniently comprise a volt-meter or frequency meter connected across the terminals of a tachometer generator C driven by the winding gear D. The movable element B responds to the position of the cage in the shaft, but is so arranged that its position is in accordance with "program" speed. It may conveniently comprise a voltmeter connected across a potentiometer resistance E, one end being permanently connected to one end of the resistance while the other end is connected to a brush F movable over studs connected to tappings on the resistance. A cam G driven by the winding gear moves the brush progressively forward from a position in which, at the beginning of the wind, it engages a stud connected to that end of the resistance to which the voltmeter B is permanently connected. The brush moves to



increase the fraction of resistance across which the voltmeter is connected in accordance with the position of the cage until the latter has reached a position at which it may be permitted to run at full speed, when the brush remains at rest until the end of the wind is being approached when the brush is moved back again by the cam towards its original position. The two instruments are placed with the axes of their movable elements in line and are designed so as to require identical scales. The instrument A carries a stem terminating in a pointer H bent downwards from the top of a cylindrical scale. The instrument B carries a stem J terminating in a similar pointer which moves immediately behind the pointer H. So long as actual speed is the same as "program" speed the pointer H lies over and obscures the pointer J. The instrument then merely gives an indication of actual speed. On any deviation from "program" speed at any position during the wind, the pointer J is exposed and draws attention to the deviation; moreover the difference between the readings of the two pointers indicates the amount of deviation from "program" speed. Movement of the pointer H considerably in advance of the pointer J may close switch contacts to operate a visible or audible electrical alarm signal or to trip a relay for applying emergency braking of the winder.—*January 25th*, 1940.

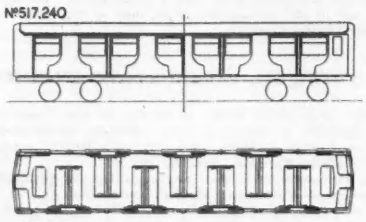
TRAMWAYS AND RAILWAYS

516,884. July 12th, 1938.—IMPROVEMENTS IN AXLEBOXES FOR RAILWAY VEHICLES, London and North Eastern Railway Company, Marylebone Station, London, N.W., and Thomas Hepple Wheatley Cruddas, 11, Westbourne Grove, Abbey Road, Darlington.

This invention relates to axleboxes for railway vehicles with more especial reference to spring supporting wagon axleboxes and has for its object to provide an improved light and durable construction. A fabricated axlebox, according to the invention, comprises a box proper, including a single plate of sheet metal pressed to shape so as to form the bottom and side walls of the box, closed at its upper end by a cast or drop stamped cap rendered integral with the box by welding, with channel members for the horns of the axlebox guide attached by welding with the sides of the box. Preferably the top is a drop stamping having a cavity or spring seat on its upper face and the channel members or horn guides are rolled sections of a length substantially equal to the overall height of the box proper, thus affording an effective reinforcement rendering the box sufficiently strong to withstand shocks and impacts. The rear of the box may be closed by a back plate and a dust shield plate of sheet metal, both apertured to pass the axle and both welded to the axlebox and the top thereof. A sheet metal front or door pivotally mounted for convenience when oiling is located in a recess or framework provided for the purpose in the front aperture of the box.—*January 15th*, 1940.

517,240. August 12th, 1938.—IMPROVEMENTS IN RAILWAY CARRIAGES AND THE LIKE, William Sebastian Graff-Baker, 4, Edwardes Square, Kensington, London, W.8, and London Passenger Transport Board, 55, Broadway, Westminster, London, S.W.1.

According to the invention compartment stock carriages are constructed so that a gangway is left at one end of each partition between compartments alternately at each side of the carriage, so that one partition projects from an offside wall and terminates short of the near side wall and the next is reversely arranged

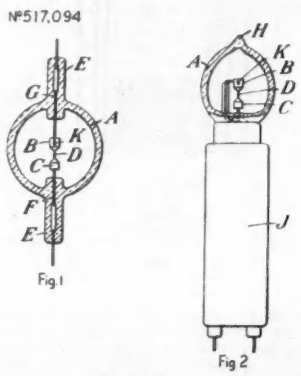


projecting from the near side and terminating short of the off side, and so on. A sinuous communication is thus formed along the carriage from one compartment past the end of its partition into the next compartment, along that compartment transversely of the carriage, past the end of the next partition into the next compartment, along that transversely of the carriage again and past the end of the next partition, and so on. The side walls opposite the cut back ends of the partitions are cut out to provide doorways in which sliding doors are arranged which slide into the "solid" parts of the side walls and overlap each other therein when opened.—*January 24th*, 1940.

LIGHTING AND HEATING

517,094. August 18th, 1938.—HIGH-PRESSURE METAL-VAPOUR ELECTRIC DISCHARGE LAMPS, *The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2.*

Lamps of the type described in this specification are much used for optical projection. According to the invention in a HPMV lamp the electrodes are located relatively to the envelope so that the discharge column is displaced substantially from the centre of the envelope and obstructing means are provided (also necessarily displaced from the centre) on which the image of the discharge column falls, whereby light from the image cannot, but light from the discharge column can, issue on the side of the obstructing means opposite to that on which the image falls. The obstructing means may conveniently be part of the electrodes or of their supports. In each of the accompanying illustrations, A is an approximately spherical quartz envelope, B, C conical electrodes between whose adjacent apices the



discharge column D passes. The lamp of Fig. 1 is double-ended; it has a seal E at each end; through one seal passes the conductor F supporting the electrode C, through the other the conductor G supporting the electrode B. The lamp of Fig. 2 is single ended; the envelope is terminated at the top by a sealing off pip H, at the other by a double seal lying within the cap J. The envelope is filled as usual with rare gas and a drop of mercury, all evaporated in operation, yielding a pressure of some 40 atmospheres. According to the invention (this is where the novel point resides), the point midway between the electrodes lies well below the centre of the envelope and so that the image A of the discharge column, formed by reflection at the inner surface of the envelope, falls on one of the electrodes. Light from the image cannot then reach the projecting optical system, which is on the opposite side of the electrodes.—*January 19th*, 1940.

METALLURGY

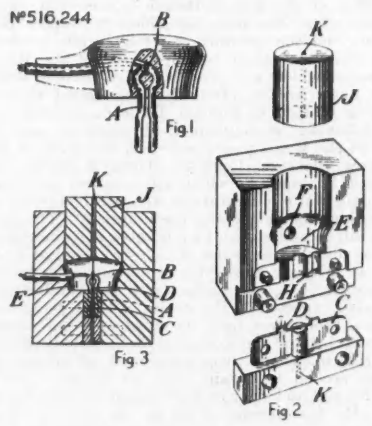
517,731. July 2nd, 1938.—IMPROVEMENTS IN ALUMINIUM ALLOYS, High Duty Alloys, Ltd., and William Eliezer Prytherch, both of 89, Buckingham Avenue, Trading Estate, Slough.

The aluminium alloys referred to are more especially those intended for the manufacture of parts such as internal combustion engine pistons required to have good mechanical properties at high temperatures. The aluminium base alloy of enhanced mechanical properties at high temperatures includes from 1–7 per cent manganese, 0·5–5 per cent. calcium, 1–7 per cent. silicon, 0·5–3 per cent. magnesium, and 0·5–2 per cent. copper, with or without small proportions of other constituents such as nickel iron up to 1·7 per cent., chromium to 0·5 per cent., or titanium up to 0·5 per cent. The combined proportions of nickel with copper should not exceed 3 per cent, with iron 2 per cent., and with chromium 2 per cent., and conveniently in selecting the optional constituents for inclusion in the alloy preference is given to those elements which are known to have a hardening effect on aluminium alloys and to this end also the alloy may be heat treated, hot worked, and aged or precipitation hardened by any of the conventional treatments. A preferred embodiment of aluminium alloy for forged pistons comprises: manganese, 2·5–3·2 per cent.; calcium, 1·0–1·5 per cent.; silicon, 2·2–2·7 per cent.; magnesium, 1·4–1·6 per cent.; copper, 1·4–1·7 per cent.; chromium, 0·25–0·40 per cent.; iron up to 0·3 per cent.; aluminium, remainder. The forged alloy is advantageously subjected to a solution heat treatment at 520–530 deg. Cent. for two hours followed by quenching, then a precipitation heat treatment at 160–170 deg. Cent. for sixteen to twenty hours, again followed by quenching.—*February 7th*, 1940.

MISCELLANEOUS

516,244. June 22nd, 1938.—SINGLE AND MULTIPLE CONTACT ELECTRICAL TERMINAL CONNECTORS, Charles Reginald Cook, of Chesworth, Horsham, Sussex.

The invention comprises improvements in single and multiple contact electrical terminal connectors (*i.e.* plugs and sockets) and relates to connectors in which the contacts are partly or wholly embedded in rubber supports by moulding the rubber around the contacts or around the heads thereof. The plug illustrated in Fig 1 is nickel plated over the eye end to prevent reaction between the metal of the pin and some of the constituents of the rubber. In the manufacture of the plug the ends B of a length of thin flex are bared and tied around the eyes of the two pins respectively and are then soldered in position. The two pins are then placed, like a pair of clothes pegs, in spaced parallel relationship on a strip C of metal (Fig. 2), forming part of the mould, one of the pins being indicated in dotted lines. The metal strip passes edgewise between the arms of the pins for about half the length thereof and in addition the strip has a pair of tongues D appropriated to each of the pins respectively and extending between the arms of the pins up to the eyes. These tongues serve to prevent the moulding material



being forced between the arms of the pins. The strip C carrying the two pins is then clamped between the two parts E of a hollow mould, the plugs being threaded through a hole F in the mould extending at right angles to the length of the pins and the edge of the metal strip lying flush with the bottom of the mould. The part of the arms of the pins which are to be outside the support are received within holes or sockets H formed in the mould. The mould is of substantially cylindrical form divided diametrically and is provided with a cylindrical plunger J. One or more spew-holes K are provided to take excess pressure off the moulding. The moulding material is a suitable rubber composition and when the pins and the strip have been placed in position as described above, and as shown in Fig. 3, the mould is filled with the composition and pressure is applied by the plunger. Heat is then applied to vulcanise the rubber, and finally the two halves of the mould are separated and the metal strip is drawn from the pins to release the plug. During the moulding operation the rubber is pressed in the eyes of the pins and may completely fill them thereby providing an effective anchorage for the pins in addition to the support given by the rubber surrounding the eyes. On the other hand the metal tongues D prevent any rubber being forced between the arms of the pins which remain spaced apart as shown in Fig. 1 and free to move resiliently towards each other when the plug is inserted in a socket.—*December 28th*, 1939.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Ex-Siemens' Men

Friday, March 29th.—Gatti's Restaurant, William IV Street, Strand, W.C.2. Smoking Concert. 7.30 p.m.

Institution of Automobile Engineers

Tuesday, April 2nd.—Royal Society of Arts, John Street, Adelphi, W.C.2. "Modern Applications of Cast Iron in Automobile Construction," E. C. Toghill and R. V. Dowle. 6.15 p.m.

Institution of Chemical Engineers

Friday, April 5th.—Hotel Victoria, Northumberland Avenue, W.C.2. Annual Corporate Meeting and Presidential Address. 11 a.m. Luncheon, 12.45 for 1 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tuesday, March 19th.—39, Elmbank Crescent, Glasgow, "A Modern Approach to Building Technique," A. Miller. 6.30 p.m.

Tuesday, March 26th.—39, Elmbank Crescent, Glasgow. "Modern Steam Propelling Units and their Possibilities for Cargo Steamers," J. B. O. Sneeden. 6.30 p.m.

Institution of Production Engineers

Saturday, March 16th.—Yorkshire Section. Hotel Metropole, Leeds. "Progress in Machine Tool Design," R. C. Fenton. 2.30 p.m.

Junior Institution of Engineers

Friday, March 29th.—39, Victoria Street, S.W.1. "Gas Producers as applied to Transport Purposes," R. Lowe. 6.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, March 29th.—Mining Institute, Newcastle-upon-Tyne. "Air Conditioning of Passenger and Cargo Spaces," W. H. Glass. 6 p.m.

Railway Club

Thursday, April 4th.—57, Fetter Lane, E.C.4. "Railway Amalgamation Prior to 1921," K. Brown. 6.15 p.m.